SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1923.

GENERAL PHYSICS.

2045. *The Quartz-Fibre Manometer.* **A. S. Coolidge.** (Am. Chem. Soc., J. 45. pp. 1637–1643, July, 1923.)—Carver has recently shown [Abstract 622 (1923)] that ordinary forms of micromanometer are not suited for use with organic vapours. But the quartz-fibre manometer, invented by Haber and Kirschbaum, is here modified by having two fibres supported 1 cm. apart at the top, each 9 cm. long, and at the bottom joined together on a small glass tip. As in the simple form first invented, the damping of the system set swinging in a vacuum is observed by a telescope and the vacuum pressure is deduced from the damping. The advantages claimed for the present form are that the bifilar system has one instead of two degrees of freedom; and the mass of the glass tip lowers the frequency of vibration and renders the measurement of damping more accurate. A McLeod gauge is not reliable except with permanent gases; so in comparing its readings with those given by the present form a special form of McLeod gauge is used in which the troubles arising from the adsorption of the gas by the walls of the tubing used is minimised. The conclusion is reached that for condensable gases the instrument described is reliable up to pressures of 0·1 mm. or 1·0 mm., depending on the gas used. P. E. S.

2046. *A Photographic Method to Render Evident Small Deformations in Straight Objects.* **L. Bull.** (Comptes Rendus, 176. pp. 1612–1613, June 4, 1923.)—The objects are photographed foreshortened, so as to show up the deviation from the straight line. An ordinary image of the object is projected so as to lie horizontally on a screen with a narrow vertical slit; behind this is a photographic plate, which moves continuously perpendicular to the slit. The image moves in the same direction over the slit, with a larger velocity, and the resulting impression on the photographic plate is shortened, while the vertical deviations from the straight line remain the same. The method can be combined with the cinematograph, and the paper shows the result obtained with a bowed violin string. H. N. A.

2047. *The Recording Ultramicrometer.* **J. J. Dowling.** (Phil. Mag. 46. pp. 81–100, July, 1923. Nature, 111. pp. 742–743, June 2, 1923.)—

Practical hints are given as to the setting up of this instrument [see Abstract 2 (1922)]. P. E. S.

2048. *Optical Strain Gauges and Extensometers.* **L. B. Tuckerman.** (Engineering, 116. pp. 222–223, Aug. 17, 1923. Paper read before the Am. Soc. for Testing Materials, June, 1923.)—Describes briefly the various forms which have been adopted for the optical level used in extensometers. These forms may be classified as (*a*) uncollimated, (*b*) collimated and (*c*) autocollimated. Of these the latter is most convenient and has been adopted in the instrument described in the paper. The authors use a three-mirror system. Two mirrors are fixed together practically at right angles, and a third, relatively movable, is nearly at right angles to these two, its axis of rotation being practically perpendicular to the line of intersection of these fixed pairs. A reading can be taken from almost any position in front of the three mirrors, and the image of the fiduciary mark in the observing field is steady, even with a vibrating or rotating mirror system. There is, of course, a cosine error. This is eliminated by using a small auxiliary mirror to convert it effectively into a combination of double and triple mirror systems, thus producing a "flash" as the collimator passes through the perpendicular position. Whenever the "flash" is within the field of view, the deviation from the perpendicular is so small that the cosine error is negligible. For use with an auto-collimator the mirrors must have very accurately plane surfaces. These are more easily obtained in prisms than in ordinary plane mirrors. It is readily possible to read to an accuracy of four-millionths of an inch on a two-inch gauge length. J. W. T. W.

2049. *The Rise of Motive Power and the Work of Joule.* **C. A. Parsons.** (Manchester Lit. and Phil. Soc., Mem. 67. pp. 17–29, June, 1923. Joule Memorial Lecture.)

2050. *Determining Apparent Densities.* **K. K. Dodds.** (Chem. and Met. Eng. 29. pp. 324–325, Aug. 20, 1923.)—If D = density, W = weight, and V = volume of a body, $D = W/V$. If the weights in air and liquid are denoted by W_1 and W_2 respectively, and the density of the liquid by *d*, then $D = W_1/(W_1 - W_2) \cdot d$, or if water is the liquid used the term *d*, unless great accuracy is required, may be neglected. Densities of continuous substances, *e.g.* glass and metals, as determined by the above equations are *actual* densities, whilst in the case of porous materials, *e.g.* coke and brick, the first equation only gives the *apparent* density of the body as a whole. If the porous substance is boiled at atmospheric pressure in water and the saturated weight is denoted by W_3 and the apparent density by D_a, then $D_a = W_1/(W_3 - W_2)$. The author shows that accurate results can also be obtained without boiling. A porous body weighing W_1 grammes in air when suspended in water has an immersed weight W_2 grammes. After reweighing in air the weight is W_3 grammes, hence the weight of water taken up is $(W_3 - W_1)$. If no absorption of water had taken place, the true suspended weight would be $[W_2 - (W_3 - W_1)]$. Hence the volume of the body is $\{W_1 - [W_2 - (W_3 - W_1)]\}$ c.c., and the apparent density is $D_a = W_1/\{W_1 - [W_2 - (W_3 - W_1)]\}$ which gives on reduction $D_a = W_1/(W_3 - W_2)$ as above. A description of the apparatus used and tables of results are given. T. C. H.

2051. *Density Determinations.* **A. C. Egerton and W. B. Lee.** (Roy. Soc., Proc. 103. pp. 487-499, June 1, 1923.)—The sources of error arising in the various well-known methods of density determination are discussed. The Archimedes method is rendered more accurate by utilising certain mobile heavy organic liquids—ethylene dibromide and carbon tetracholride—with which damping is mimimised and air-bubble difficulties disappear. The suspension difficulty is overcome by separate determinations of the parts immersed and not immersed. An arrangement is described by which the preparation of a satisfactory sample of the metal (lead) for density determination is rendered possible by filtering, casting, and heating *in vacuo*. The density of lead is 11·3437 at 20° C., with probable max. error 1/100,000. A sample of uranium lead has an atomic weight of 206·26 as calculated from the density obtained by the present methods. A. B. C. L.

2052. *Investigation of the Hopkinson Pressure Bar.* **J. W. Landon and H. Quinney.** (Roy. Soc., Proc. 103. pp. 622-643, July 2, 1923.)—A systematic treatment of the theory and practice of pressure measurement with the Hopkinson pressure bar. The paper deals in seven sections with various points. The effect of coning the bar as usually practised, renders comparative tests useless unless the pressure-time curve is similar for each explosion or impact. Besides practical examples, a theoretical investigation of this point is given. The effect of length of the bar on the form of the pressure wave involves three effects; (i) Due to the overstrain near the firing end of the bar, (ii) to non-uniform distribution of pressure over the firing end, and (iii) to change of type due to the lateral contraction component of the wave motion. Results showing the variation of mean pressure with the diameter of the bar indicate that the pressure falls off rapidly with the distance from the axis. The variation of mean pressure with the distance between the charge and the bar is illustrated, and the maximum pressure obtained by detonating a tamped charge of gun-cotton in contact with a short bar shown to be 117 tons/square inch. The effect of detonating a charge of gun-cotton in contact with the end of a bar of concrete is to demolish entirely a length and to throw off a series of lengths to different distances. Calculation of the maximum transmitted pressure agrees well with the tensile breaking point of the material. A. Wh.

2053. *A Recording Chronograph for the Inverse Rate Method of Thermal Analysis.* **H. J. French.** (Bureau of Standards, Technol. Papers No. 230. pp. 245-255, Washington, 1923.)—A description of a recording instrument for direct plotting of curves for the inverse rate method of thermal analysis in which the time interval required for a definite temperature change and the temperature are the coordinates. The original should be consulted for details of the construction. E. G.

2054. *Comparison of Clock Corrections Determined with Large Instruments.* **H. R. Morgan.** (Astron. J. 35 pp. 4-7, Feb. 20, 1923.) Intercomparisons of wireless time signals show that there are large variations in the times sent out from various observatories, and these may be due to the observations. The author has made comparisons of clock corrections taken within a few hours on the same night with the 9-inch and the 6-inch transit circles of the U.S. Naval Observatory, these instruments being permanently mounted in identical large buildings. Many adjustments were made that might affect the continuity of clock corrections. During the five years, 1913.5–1918.5, there were 397 clock corrections, determined nearly simultaneously on the two instruments, and it was found that variations due to the clamp positions of the instrument gave differences as much as 0·2s. or more. Such clamp terms must be taken account of in absolute time or longitude work, but this cannot be done when preliminary reductions have to be made for a time signal sent out within a few hours of the observation, and though a mean value of the clamp term could be applied, yet the change with clamp itself varies more than 0·1s., and the author infers that this may be due to discordances between observations. [See Abstract 847 (1923) and next abstract]. A. S. D. M.

2055. *Accuracy of Time Determination.* **H. R. Morgan.** (Astron. J. 35. pp. 80–83. Aug. 10, 1923.)—Determination of time from astronomical observations are provisional or definitive; the former being when a signal is sent out which itself indicates true time, and it is necessary to predict the corrections to a standard clock from provisional observations; in the definitive reductions, the personal equations are determined, the solutions for clock rates extend over longer periods than in the provisional, definitive positions of clock stars are used, examinations for clamp differences are made, and erratics in clock and chronograph systems studied. The author gives examples of the running of clocks and their normal or outstanding corrections, and of the observational errors of transit instrument [see preceding abstract] and shows that Prof. Sampson's comparison of the wireless time signals sent from Washington, Paris, and Berlin and received at Greenwich, Uccle, and Edinburgh (M.N. Jan., 1922), might be considerably modified in the light of these. He suggests instrumental and observational reasons for the discrepancies, and considers that the variations in times determined at large observatories are more or less due to the provisional nature of the astronomical observations, and reductions used; that by planning properly the provisional work, the variations in the preliminary times may be partly eliminated and partly corrected for by later definitive reductions; and that longitude determinations need not be subject to such uncertainties. He suggests for provisional signals that observations of zenith stars be taken on small and quickly reversible instruments, whose behaviour has been studied, and that standard instruments in fixed observatories should receive a few, but the same signals, periodically for long periods of time under all conditions, for help in the determination of longitudes. A. S. D. M.

2056. *Uniform Clock Rates for Period of Entire Year.* **M. L. Zimmer.** (Astron. J. 34. pp. 196–199, Jan. 26, 1923.)—Fundamental observations made at Cordoba in 1913 showed that evening clock corrections were larger than morning ones. To test this, two Riefler clocks, Nos. 155 and 330, were installed in the subterranean clock room under strictly uniform conditions, and there was no known disturbance of the clocks from Sept., 1919, until Oct., 1920; after this date there were frequent earthquakes. During the calm period, 15,000 observations were made to investigate the night and morning rates and these could be represented by the formula: $\Delta t_0 + at + bt^2 + c \sin 2\odot + d \cos 2\odot$

$+ e \sin 5\odot + f \cos 5\odot = \Delta t$; where Δt_0 = mean clock correction; t = number of days from Feb. 29; and $\odot$ = sun's true longitude for date of observation. A smooth curve was computed for the part of the rate depending on $2\odot$ and the observations, freed from that part of the rate depending on t and t^2, were superimposed upon it. There can be no doubt about the reality of this curve, and since both clocks trace out the same curve during the period, and glimpses of it are found in the shorter periods of uninterrupted clock rates, there is every reason to suppose that it will be repeated in subsequent years; but no explanation as yet is found for it. The author points out the value to fundamental work of such rates, since thereby whole years of observation may be reduced in the same manner as those of a single night. A. S. D. M.

2057. *An Impulse Electric Motor for Driving Recording Instruments.* **W. F. Joachim.** (Frank. Inst., J. 196. pp. 215–226, Aug., 1923.)—The motor was designed to drive the film drums of recording aircraft instruments, where lightness and regularity in speed are essential; it was built much like a standard telephone relay, with double opposed electromagnets; these alternately pull the armature, which is mounted on leaf springs between them, from one pair of pole-faces to the other; the ends of the armature carry pawls, which engage with a ratchet wheel, driving the film drum; on one stroke one of these pawls drives the ratchet wheel forward a step, while the other ratchets back over the wheel into position for the next stroke. The alternate energising and de-energising of the pairs of electromagnets is accomplished by a distributor driven by a variable-speed motor, which makes and breaks the circuit for each electromagnet once in each revolution; the speed of this motor can be regulated closely through a large range; and as there are 240 teeth on the ratchet wheel it is turned at a low speed which can be closely regulated between 0 and 35 r.p.m. Absolute synchronism between any number of motors can be obtained by connecting them to the same distributor; the motor measures 3·49 cm. × 3·02 cm. × 2·22 cm., weighs 75 grammes, consumes 0·1 to 0·9 amps. at 8 volts, max. torque 269·6 gr. cm., max. power 6×10^{-5} h.p., max. efficiency 0·99 per cent; this is a high efficiency for the output. The normal speed is obtained at once on closing the switch, and the motor stops dead when the switch is opened; the life is long owing to low bearing pressures, and the cost of construction is low owing to the few parts, the spool type coils, and the elimination of rotating contacts and brushes. H. N. A.

2058. *Mercury-Vapour Pump.* **L. T. Jones.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 537–538, July, 1923.)—A description of a new glass mercury-vapour pump with certain innovations in design, rendering it less fragile than the usual kinds and giving very consistent and satisfactory performances. There are a large number of jets, made "cockle burr" fashion, the openings being 0·5 mm. or less in diameter, through which the mercury-vapour escapes from the reservoir. The action is the same as that of other vapour pumps. [See Abstract 1050 (1922).]
T. C. H.

2059. *Coefficients of Viscosity and of Slip of Air and of Carbon Dioxide by the Rotating Cylinder Method.* **K. S. van Dyke.** (Phys. Rev. 2. pp. 250–265, March, 1923.)—A new determination is made of the coefficient of viscosity of dry air, employing Millikan's apparatus as used by Gilchrist, Harrington, Yen, and Stacy, the value obtained, $\eta_{23} = 1822 \cdot 1 \times 10^{-7}$, being only 1/40 % less than Harrington's standard value. By the same method, for CO_2, $\eta_{23} = 1471 \cdot 5 \times 10^{-7}$, which value is considered correct to within 1/20 %. Coefficients of slip for rough and smooth surfaces in air and CO_2 are computed from values of the apparent coefficients of viscosity measured by this method for pressures of 0·5 to 0·1 mm. For an old shellac surface, the values found both for air and CO_2 are only 3 % greater than the theoretical lower limit computed by Millikan for a completely diffusing rough surface. For a surface coated with watch oil the coefficients in air and CO_2 are found to be 21 % and 12 % higher respectively, which agrees with the corresponding values found by Millikan's oil-drop method. For clean and scratched brass surfaces intermediate values are obtained. The fatigue effect of a watch-spring steel wire, twisted under load, is noted. In 5 years, a gradual stiffening is shown by a decrease of 0·09 % in the period. A twist of 8° for 30 min. is found to cause a temporary zero shift of 0·004°. A. B. C. L.

2060. *Measurement of the Viscosity and Surface Tension of Viscous Liquids at High Temperatures.* **E. W. Washburn.** (Rec. des Trav. Chim. des Pays Bas. 42. pp. 686–696, July, 1923.)—A method is described for determining the relations between viscosity, temperature, and composition, and between surface tension, temperature, and composition of the system, soda-lime-silica in the range obtained with commercial glasses. Use is made of a refractory porcelain cylinder which is submerged in an electrically heated bath containing the glass, and measurement is made of the time of rotation when a definite turning moment is applied. The equation employed is $\eta = K\frac{W}{S}$, where W is the mass of the falling weight which actuates the cylinder, and S the number of revolutions per minute. K is found to be constant for all viscosities up to 1000 poises, but for higher viscosities the value increases with the viscosity. The apparatus was first calibrated with glucose solutions, the viscosities of which were determined by different standard methods. Values for log η obtained for the glasses are plotted on isothermal space models and projected on to ternary diagrams. A series of isobars showing the logarithm of the viscosity are thus plotted for a given temperature as a function of the proportions of the constituents of the glass. From these results curves are plotted of the values of log η against temperature for different compositions over the range 800° to 1500° C.

Measurements of surface tension are made by a method in which a cylinder of platinum foil is supported by a spring and lowered into the bath until contact with the surface is made. The surface tension force which then draws the cylinder into the glass is measured by the extension of the spring. The apparatus is calibrated by the use of standard liquids. From the results obtained ternary diagrams are prepared giving at definite temperatures lines of equal surface tension. J. N. P.

2061. *The Flow of Water in the Annular Space between Two Coaxial Circular Pipes.* **T. Lonsdale.** (Phil. Mag. 46. pp. 163–169, July, 1923.) —An experimental determination of the relation between pressure gradient and mean velocity in this case. In the laminar region vel. ∝ pr. grad.

In the turbulent region $i = Cv^n$, and n has the value 1·72. The method of dimensions leads to the formula

$$i = K(b-a)^{n-3}\mu^{2-n}\rho^{n-1}v^n$$

i being the pressure gradient, b and a the outer and inner radii. K as determined varies from 0·197 to 0·231, agreeing thus with the values (0·210 . . .) obtained by Stanton and Pannell for tubes. The critical velocity between the two states of motion was quite definite, and an empirical formula,

$$v_c = \frac{4000\,\mu b}{b^2 - a^2}$$

is given, agreeing to within 5 % with the experimental values. W. G. B.

2062. *Demonstration of Steady Flow of Fluid.* **S. Hayashi.** (Kyoto Coll. Sci., Mem. 6. pp. 171–172, March, 1923. In English.)—Describes apparatus for showing stream lines in three-dimensional motion. Photographs of the stream lines past a propeller, and past spheres at rest and rotating are given. W. G. B.

2063. *A New Air Velocity Calculator.* **T. Suhara.** (Aeronaut. Research Inst. Imp. Univ. Tôkyô, Report, 1. pp. 25–30, June, 1922. In English.)—The calculator is a slide-rule with four scales, designed and graduated to obtain the air speed from Pitot tube observations at one setting, the scales being those of temperature, barometric height, difference of level read in the manometer, and air speed. Full-size drawings are given, and the manner of correcting for humidity explained. W. G. B.

2064. *An Instrument to Measure the Direction and Speed of Wind Relative to an Aeroplane.* **T. Tamaru.** (Aeronaut. Research Inst. Imp. Univ. Tôkyô, Report, 1. pp. 1–23, Feb., 1921.)—The instrument described makes use of the dependence of the pressure at any point of a cylinder against which the wind blows, on the azimuth of the point measured from the direction from which the wind comes, and records the difference of pressure for different azimuths. The space inside the cylinder is separated longitudinally so that each row of holes has its own space from which a side tube allows connection with a pressure measuring instrument. An experimental "side-slip" indicator which worked satisfactorily on an "Avro" machine is mentioned. The range of direction of the present instrument is 120°, *e.g.* when set for up-and-down angles, for any angle of attack between 20° and 100°. This will include the case of recovery from a nose-dive. The method of registering is the same as in an ordinary barograph. The inside spaces of two piles of elastic boxes are separately connected to the sets of holes on the sides, while the chamber of the barograph made airtight is connected to a middle set of holes. Formulæ relating to the pressure differences and readings obtained are given, and it is shown that there is a graphical method possible for finding the velocity from the pressure readings. It is pointed out that the use of two instruments, one with its cylinder vertical, and the other horizontal and transverse, enables the three component velocities of the wind, and the forward velocity to be measured. For use in a fixed place, as in a wind tunnel, one or two water manometers can be used with the cylinder (with the rows of holes) instead of the aneroid or barograph. A. W. J.

2065. *Electrically Deflagrated Mercury Filament as a Flashlight for Instantaneous Photography.* **K. Suyehiro.** (Japanese Journ. Phys. 1. 9–10. pp. 97–100, 1923. In English. Phys. Math. Soc. Japan, Proc. 5. pp. 91–94, June, 1923. In English.)—The use of solid wires was abandoned as being unsatisfactory, so a mercury filament was used, by which a flashlight of very short duration and of sufficient illuminating power was obtained. These filaments were made by sucking mercury into a glass capillary tube. Each end of these tubes, with a hair wire inserted, was sealed with sealing wax. The deflagration was caused by closing a circuit with the blow of a hammer on a lead anvil. For measuring the duration of the flashlight two rotating discs with radial lines were used; the displacement of the radial lines shown by photographs of the rotating disc illuminated by the flashlight from the deflagrated filaments giving the duration. The results inferred from the experiments were: (1) The duration depends upon the diameter and length of the filament, being shorter with finer and shorter filaments; (2) the duration depends upon the thickness of the wall of the capillary tube; (3) when a secondary battery is used the use of a condenser shortens the duration of the flash, but when a dynamo is used the duration is lengthened and the condenser serves no purpose; (4) the duration of the light sometimes varies even with filaments of practically the same make and deflagrated under the same conditions. When the filament attains a high temperature the capillary tube containing it explodes. Examples of the practical application of this flashlight are given [see Abstract 1063 (1921)]. T. C. H.

2066. *Errors of Observation.* **W. Burnside.** (Cambridge Phil. Soc., Proc. 21. pp. 482–487, June, 1923.)—The subject is treated mathematically. The standard formula for the probable error is arrived at by assuming (*a*) that the errors follow Gauss' law, (*b*) that the precision-constant has that particular value which makes the probability of the observed set of values as great as possible. The alternative formula presented in the present paper, which gives a smaller value for the probable error, is arrived at by making the same first assumption and replacing the second by the assumption that *a priori* all values of the precision-constant are equally likely. A. B. C. L.

2067. *The Theory of Mensuration.* **Dorothy Wrinch and H. Jeffreys.** (Phil. Mag. 46. pp. 1–22, July, 1923.)—A law is defined as an observed relationship common to many sets of data. *A priori* the simplest law is the most probable. The theory of mensuration is examined in this light. The ideas of "distance" and "rigid bodies" are examined and definitions of them, founded on observation, are given. Firstly, a body is recognised as something on which it is possible to make recognisable marks. If, then, two marks on the "edge" of a body are in contact with the "edge" of another body, and all intermediate points remain in contact however the two bodies are turned, the two "edges" are defined as "straight." Two "straight edges" can always be made to coincide in this way. If, under certain conditions, they cannot, the bodies cannot be "rigid" and the edges cannot be considered as "straight" for the purposes of mensuration. The conditions that two "marks" on a "straight edge" should be at a greater, equal, or less distance than two other marks on another "straight edge," are discussed and defined in the usual way. The idea of distances between points not on a straight edge is also introduced with the help of caliper comparison. Also the idea of a scale is introduced. The relation of mensuration to geometry is not simple. Geometry is intensive, mensuration extensive, but it may be found that the fundamental observations of mensuration may be comparable with the fundamental postulates of a geometry. Euclidean geometry bears more resemblance to mensuration than any other, but some of Euclid's postulates are unsupported and some, when applied to mensuration, manifestly false. This is particularly obvious in Euclid's treatment of parallels. In the logical development of a theory of mensuration it is unsound to introduce the idea of angle except as derived from certain lengths. To do this the following experimental relation can be assumed with very high probability to be true. Let two straight edges meet at 0 and x and y be marks, one on each. Then in general:

$$\frac{\partial}{\partial\, ox}\left(\frac{ox^2 + oy^2 - xy^2}{2\,.\,ox\,.\,oy}\right) = 0$$

$$\frac{\partial}{\partial\, oy}\left(\frac{ox^2 + oy^2 - xy^2}{2\,.\,ox\,.\,oy}\right) = 0$$

and each ratio is less than unity. This leads naturally to the definition of angle as:

$$\cos^{-1} x = \int_x^1 \frac{du}{(1 - u^2)^{\frac{1}{2}}} \quad \text{where } x = \frac{oa^2 + ob^2 - ab^2}{2oa\,.\,ob}$$

A number of definitions relating to planes and Cartesian coordinates are then developed in detail. A. Wh.

2068. *Universal and Other Constants.* **E. Karrer.** (Frank. Inst., J. 196. pp. 79–87, July, 1923.)—In the course of a general review of the nature and development of constants it is suggested that there is probably no constant in the absolute sense in which it is ordinarily looked upon in practice. A classification of constants into five groups is given in tabular form and includes: (1) Independent universal constants applying to all matter, all electricity and to all processes, from which all other constants may be derived, *e.g.* velocity of light in free space, electronic charge, etc.; (2) derived universal constants independent of materials, *e.g.* mass of neutral resting hydrogen atom, number of grammes per gramme-molecule, etc.; (3) reference points by definition or experiment, *e.g.* freezing-point of water, atomic heat of solids, etc.; (4) conversion factors, *e.g.* mechanical equivalent of heat; and (5) constants describing properties of materials and instruments. Diagrams are given suggesting the relationships between the constants and groups of constants.

A. B. C. L.

2069. *The Eötvös Torsion Balance in the Field.* **H. Shaw** and **E. Lancaster-Jones.** (Nature, 111. pp. 849–851, June 23, 1923.)—After a brief description of the instrument, an imaginary example is worked out of a dense layer supposed to be 200 metres below the earth's surface. A graph is given showing how the gravitational field varies in the neighbourhood, and how this variation influences the readings of the balance. [See also Abstract 1728 (1923).] P. E. S.

2070. *Lateral Vibrations of Rods of Variable Cross-Section.* **Dorothy M. Wrinch.** (Phil. Mag. 46. pp. 273–291, Aug., 1923.)—The investigation referred to in Abstract 603 (1923) is here extended to thin bars of certain other very general types. W. R. C.

2071. *Electrical and Mechanical Vibrations.* **L. Schüler.** (Elekt. Zeits. 44. pp. 637–640, July 5, 1923. Paper read before the Elektrot. Verein.)—Semi-popular descriptive account of the analogous cases of vibration in the electrical and mechanical regions. The paper is illustrated by diagrams and views of apparatus. E. H. B.

2072. *On the Paradox of D'Alembert.* **D. Riabouchinski.** (Comptes Rendus, 176. pp. 1128–1131, April 23, 1923.)—If a body is set in motion in a perfect fluid, the motion will be permanent, provided "cavitation" does not occur. The effects of cavitation may be simulated by variable sources and sinks, together with vortices. The complex velocity potential-stream function is given for two-dimensional motion about a circular cylinder and an infinitely long strip. W. G. B.

2073. *Motion of Sphere in Rotating Liquid.* **S. F. Grace.** (Roy. Soc., Proc. 104. pp. 278–301, Sept. 1, 1923.)—Both in its specification and mathematical treatment the problem here dealt with is in every way the analogue of that dealt with in an earlier paper [Abstract 626 (1923)] with the sole exception that, whereas the small initial impulse given to the sphere was in the former case parallel to the axis of rotation, it is here at right angles to that axis. The pressure intensity of the liquid consists of two parts as before, but that depending on the distance from the axis would now tend to maintain the sphere in relative rest. The initial disturbed motion will be irrotational, and symmetrical with respect to the equatorial plane of the sphere, and will so continue, the subsequent motion of the centre being wholly in this plane. The path of the centre of the sphere is a spiral with a definite limiting point, about which the sphere winds in a direction opposite to that of rotation of the liquid, while continuously approaching the point with a speed tending to zero. The motion persists longer than in the former case, and is practically confined to the neighbourhood of the sphere, but less so than before. The velocity components are oscillatory and tend to zero as the distance from the sphere increases. On the axis of the sphere the motion is perpendicular to the axis and persists with time. At a point on the sphere the tangential velocity relative thereto is representable as the component in the tangent plane of a vector which is a generator of a right circular cone drawn inwards from the point and with its axis along the radius vector; the generator rotates with constant angular velocity and is initially opposite to the direction of projection of the sphere; the angular velocity varies with the latitude from a maximum at the poles to zero at the equator. This will apply in the former case, but was not there given. General expressions are obtained for the disturbance at any point. Combining the results of the two papers gives the small general motion of a sphere projected in a rotating liquid with a given small initial velocity, the path of the sphere being helical. Although the actual motions remain small with the time, the vorticity components tend to become large, *e.g.* on the axis of the sphere. Thus the solution gives the true state of the liquid only for a limited time. A number of curves graphically illustrating the motion are given. G. W. DE T.

2074. *Resistance of a Cylinder Moving in a Viscous Fluid.* **L. Bairstow, [Miss] B. M. Cave, and [Miss] E. D. Lang.** (Roy. Soc., Phil. Trans. 223. pp. 383–432, July 20, 1923.)—Formulæ for the resistance of a circular cylinder, and of a flat plate, moving through a viscous fluid, are obtained analytically, using the equations of motion in the form first stated by Oseen, whereby the inertia terms are to some extent taken into account. Lamb's approximation is obtained on the way. It is also indicated how the problem for other sections, such as an aeroplane wing or strut, can be solved, though in such a case the integrations would have to be carried out numerically. Comparison with experiment shows, over the limited range of Reynolds' number for which calculations and observations overlap, calculated resistance 30 to 40 % above observed. Some discussion of the functions, analogous to Green's functions, which occur in the solution is appended. The paper is mainly mathematical. W. G. B.

2075. *Compressional Waves in Metals Produced by Impact.* **R. W. Boyle.** (Roy. Soc. Canada, Trans. 16. Sect. 3. pp. 293–299, 1922.)—Using Tschudi's formula for the time of impact of two bars [Abstract 695 (1922)], and comparing with the time of longitudinal vibration of the bars, it is found that the "compressional wave" theory of impact is untenable. After a discussion of the damping of longitudinal waves, it is concluded that the probable order of the coefficient of viscosity appropriate to this is 10^5 c.g.s. Experiments showing the duration of the vibrations excited in a bar by impact are described. One end of the bar is dipped into a vessel containing water, in which is a water-tight microphone connected to a battery circuit containing the adjustable primary of an oscillation transformer. The secondary is an ionic valve circuit containing a variable condenser, giving heterodyne "beat" reception. The train of waves was sufficiently sustained to give audible beats with frequencies of the emitted note up to about 42,000 per sec. (*i.e.* well above audible pitch). This arrangement can be used to measure the frequency, and so to determine Young's modulus. W. G. B.

2076. *Contact Area of Elastic Sphere when Compressed between Flat Elastic Plates.* **J. Goodman.** (Engineering, 116. p. 133, Aug. 3, 1923.)—The area was measured by rotating the ball, under load, about the axis of load, and on removal, the portion that had been rubbing was easily distinguished. The area as found by these experiments is from 7 to 21 % greater than the theoretical. It is also mentioned that at the maximum safe load, the compressive stress at the centre of the area of contact is 210 tons/sq. in. "It is remarkable that such an enormous stress can be applied to and removed from a steel ball for hundreds of millions of times without causing fracture, but such is the case." W. G. B.

2077. *Depression of the Centre of a Thin Circular Disc of Steel under Normal Pressure.* **S. Smith.** (Roy. Soc. Canada, Trans. 16. Sect. 3.

pp. 217–225, 1922.)—A steel disc, 6·14 cm. in diameter and 0·4 mm. thick, was supported on an annular flange forming part of a vessel which could be exhausted, so that it could be subjected to varying pressure differences between its faces. The normal deflection of the centre was measured by means of a mirror connected to a small aluminium pillar mounted on the centre of the plate by a lever arrangement. Various pressures and flange diameters were used, and an empirical formula representing the results is:

$$1 \cdot 94 - \log_{10}(10w) = k(9 \cdot 7 - d)$$

w being the depression of the centre, d the inside diameter of the flange, and k a quantity depending on the pressure, to be read from a graph given. W. G. B.

2078. *Approach of Flat Elastic Plates under Load, when Separated by a Ball of Similar Material.* **J. Goodman.** (Engineering, 116. pp. 244–246, Aug. 24, 1923.)—The object of the investigation was to see how nearly the formulæ due to Hertz were accurate in practice, in view of the increasing loads to which ball bearings are being subjected, and to obtain data for larger balls than have been previously subjected to experiment. Hertz's formula gives $\delta \propto p^{2/3}d^{-\frac{1}{3}}$, and the agreement is tolerably good. As a mean of the experiments, 0·673 is more accurate, as the index of P, than ⅔. In the case of small balls (¾″ — 3″ diam.) the observed approach is slightly greater than the calculated, but for the larger balls (4·5″ and 8″) it is slightly less. In the latter case, it is doubtful whether the ball is evenly hardened throughout, and this may be the explanation of the difference of behaviour noted. W. G. B.

2079. *Some Experiments on Impact.* **J. Okubo.** (Tôhoku Univ., Sci. Reports, 11. pp. 445–461, Dec., 1922. In English.)—By a photographic method, similar to that of Raman [Abstract 227 (1919)] the time of impact and the coefficient of restitution for spheres of various materials is determined. It is found that as the relative velocity before impact increases, e decreases, fairly rapidly at first, but, beyond a certain velocity, a linear relation holds. The time of contact also diminishes with increasing velocity of impact, but Hertz's theory is not verified. The volume of the dent is found to be directly proportional to the loss of kinetic energy. W. G. B.

2080. *The Strength of Materials.* **W. E. Dalby.** (Roy. Soc., Proc. 103. pp. 8–25, April 3, 1923.)—A modification of the testing machine and the elastic recorder [Abstract 1520 (1920)], so that records can be taken of alternating loading between tensile and compressive limits, is described. The outstanding features of the diagrams obtained are, that during the removal of a load after overstrain, the material responds in an elastic manner although the elasticity is imperfect; that during the increase of load of opposite sign to that of the load removed, although at first the response of the material is approximately elastic, plastic extension is combined with it and the plastic extension rapidly increases until a yield load is reached, after which the extension is almost wholly plastic at a constant or slightly increasing load.

A new instrument, the elastic torque twist recorder, is also described and is used for recording the torque and the elastic twist which it produces on a suitably formed test piece. Comparing the records obtained by the elastic torque twist recorder with the push-and-pull records, there is a striking similarity of form. Both show: An elastic line and a limit of proportionality; a definite yield of the material followed by plastic flow; an imperfectly elastic line as torque is removed; and a rapid progress to the plastic state when the torque is reversed in sign. The general conclusions from the two types of records are as follows: An overstrain means an elastic deformation of the crystalline substance of the blocks, combined with a relative sliding of parts of the blocks along gliding planes within themselves. A removal of load means elastic recovery of the deformed crystalline substance without plastic recovery. The imperfect elastic recovery is probably due to the influence of the plastic slips although no substantial plastic recovery takes place. The application of a load of opposite sign produces first elastic deformation of the crystalline substance, then begins to restore the slipped layers to their primitive relative positions either along the old planes of sliding or along new ones. The load being continued, the primitive positions are passed and plastic deformation continues. Removal of the load again allows elastic recovery of the plastically deformed structure. This kind of action continues up to the point of fracture. The crystalline structure is never entirely destroyed, however severe the cold working. So that, just before the actual fracture, the bulk of the metal probably consists of crystalline substance interspersed in all directions by slip planes. If, just before the plastic drawing out to fracture the load is removed, the crystal debris still exhibits imperfect elastic property. Fracture means therefore the disruption of the metal by shearing along slip planes without anything like complete destruction of the crystal structure, so that elastic property is retained up to and after fracture has taken place. C. O. B.

2081. *The Crossed-Orbit Model of Helium, its Ionisation Potential, and the Lyman Series.* **L. Silberstein.** (Astrophys. J. 57. pp. 257–263, June, 1923.)—*The Energy Formula for Crossed-Orbit Model of the Normal Helium Atom.*—From simple dynamical considerations it is shown that the energy of the model, with the two orbits assumed as rigorously circular, is given by the formula, $E = -7N_\infty ch\left[1 - \frac{1}{4\pi}F\left(\frac{i}{2}\right)\right]$, where i is the mutual inclination of the planes of the two orbits and F is the complete elliptic integral of the first kind. From this general formula it is found that for Bohr's model, in which $i = 120°$, the ionising potential is 24·35 volts, as compared with 24·5 volts recently obtained by Lyman. By means of the formula for the wave-lengths of the emitted radiation, $\nu = N\left[3 - \frac{7}{4\pi}F\left(\frac{i}{2}\right)\right]$, it is found that the simple rational values, $-\cos i = \frac{5}{9}, \frac{3}{5}, \frac{2}{3}, \frac{4}{5}$, correspond to the lines, $\lambda_1 = 584{\cdot}4$, $\lambda_2 = 537{\cdot}1$, $\lambda_3 = 522{\cdot}3$, and $\lambda_4 = 515{\cdot}7$, of the Lyman series. The author disclaims any responsibility for the dynamical legitimacy of the model. In an appended note two more lines are shown to be covered by $-\cos i = \frac{5}{6}$ and $\frac{7}{13}$, and a regularity of the whole array of fractions is pointed out. AUTHOR.

2082. *The Neutral Helium Atom.* **A. Sommerfeld.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 509–515, July, 1923.)—Hitherto atom models of the helium atom have neither agreed with its magnetic attributes or the ionisation potential. A model is discussed in which the two electrons revolve in opposite directions in coplanar ellipses, the apses being opposed. The model agrees with Millikan's observation that α particles can expel two electrons from helium atoms, since in the second half of any period, one electron would experience exactly the same action as had the other electron in the half period preceding. A private communication from **W. Heisenberg** shows that the ionisation potential of such a model would be 24·5 volts, in good agreement with Lyman's experimental value. A. Wh.

2083. *A Static Model of the Hydrogen Atom.* **H. S. Allen.** (Nature, 112. pp. 340–341, Sept. 1, 1923.)—While the Bohr atom is satisfactory the Bohr molecule leaves much to be desired as well as causing much confusion of thought by its dynamic nature. If the normal electrostatic force e^2/r^2 is supplemented by a "quantum" force e^2a_n/r^3 which is repulsive for unlike charges, a_n being a radius of stable equilibrium, a static model can be constructed for the hydrogen atom, molecule and H_3, as well as for the positively charged hydrogen molecule. The ionisation potentials of the models are in fair agreement with observation, and decisive difference between those of the positively charged molecules on the static and Bohr theories pointed out as a likely criterion. The static theory has yet to explain the secondary spectrum of hydrogen. A. Wh.

2084. *Octet Stability and Atomic Volumes in Compounds.* **R. Fraser** and **J. E. Humphries.** (Phil. Mag. 46. pp. 331–334, Aug., 1923.)—Induced alternate polarity is only manifested when an electron passes from an unstable to a stable octet. This is manifestly true for such a compound as NaCl and there is no reason for assuming a different mechanism in less strongly polar compounds. Octet stability accompanies high reactivity, in fact ionisation may occur in extreme cases, and an investigation of the equivalent volumes of the chlorine atoms in the chlorbenzenes shows that while the introduction of octet stable chlorine increases these, octet unstable atoms reduce them. Direct evidence on the size of octet stable and unstable atoms might be deduced from viscosity determinations, following Rankine, or from the *b* of van der Waals' equation. A. Wh.

2085. *An Explanation of the Theory of the Rotation of the Atomic Nucleus. Part III.* **H. Henstock.** (Chem. News, 127. pp. 18–21, July 13, 1923.)—Discusses the structure of oxides of various elements belonging to groups I, II, III, and IV, with the help of diagrams.

H. N. A.

2086. *Theory of Free Rotation.* **T. M. Lowry.** (Chem. Soc., J. 123. pp. 1866–1867, Aug., 1923.)—The formulæ used by the author, in his paper on "The Polarity of Double Bonds," represent the reactions of the various compounds, rather than the resting states of the molecules; in some cases the resting states may be identical with the reactive states, while in others, as perhaps in ethylene, the resting state is an inert molecule, which must be activated, for example, by contact catalysis, before it can unite even with a halogen; in the second case the ordinary conditions of stereochemistry will apply, until the reactive state is actually developed. It would appear that the stability of the reactive states is much less than that of the resting states; many compounds which are stable in themselves undergo inversion when subjected to chemical change, though this is not always the case and may not be spontaneous, but may depend on the action of the reagent. The fact that the three oxygens of the anion are coplanar with carbon or nitrogen in crystals of calcium carbonate and sodium nitrate, but not in lead nitrate, shows that no universal rule can be laid down; but that each case must be investigated experimentally. The original simple theory, according to which free rotation is always possible with a single bond, but impossible with a double bond, has definitely broken down. The stereochemical models of van't Hoff predict that symmetrical derivatives of phenyl can show neither stereoisomerism nor optical activity; but a case has been shown to exist where both are present. This has removed a veto on a line of research, which has already proved to be most fertile. The consideration of *cis*- and *trans*-isomerism presents some difficulties, for which an explanation is suggested. In any case it is necessary to recognise that the subject is "open to discussion on the broadest possible lines, including those suggested by the electronic theory of valency." H. N. A.

2087. *Electron Valency Theories and Stereochemistry.* **S. Sugden.** (Chem. Soc., J. 123. pp. 1861–1865, Aug., 1923.)—The statical and dynamical models of the atom are discussed in relation to valency problems. The original cubical atom of Lewis was soon seen to be incapable of representing triple bonds; and Langmuir adopted Lewis's suggestion that the eight electrons of the octet approach one another, in pairs, to form roughly a tetrahedron; this only obscures, but does not eliminate, the important objection that any arrangement of a pair of electrons forming a covalency must, in carbon compounds, allow of the free rotation of the carbon atoms about the line joining their centres, so that the electrons must be very close together. This view is open to grave objections on physical grounds, as Rutherford's investigations on the collisions of α-particles with atomic nuclei show that the inverse square law of attraction and repulsion holds up to about 10^{-12} cm.; and two electrons at any distance greater than this may be expected to repel one another. Lowry's theory of the double bond, expressed for carbon by the formula $>\overset{+}{C}-\overset{-}{C}<$, in which one pair of electrons only is shared, the bond consisting of an electrovalency and a covalency, does not seem adequate to account for the existence of geometrical isomerides; the mere superposition of an electrovalency on a covalency is not enough to account for the lack of free rotation in the double bond. A satisfactory theory of valency must be capable of representation by an atomic model, in which the number of the electrons and their mutual action is in accordance with physical laws; it must also express the chemical and stereochemical properties of known compounds. Kossel has made a beginning by a suggestive treatment of the strength of linkage in certain polar compounds, based on Bohr's dynamical atomic model. H. N. A.

2088. *The Electron in Chemistry.* **J. J. Thomson.** (Frank. Inst., J. 195. pp. 593–620, May; 737–785, June; 196. pp. 1–29, July, and pp. 145–180, Aug., 1923.)—The present series of lectures has been given before the Franklin Institute under the belief of their author that the introduction of the idea of the electron will break down the barrier of ignorance which has hitherto divided the study of the properties of matter into the two distinct sciences of physics and chemistry. The arrangement of electrons in the atom is first considered, in particular when their number is greater than 8; following which comes a discussion based upon the results obtained of the periodic law, of allotropy, and of active nitrogen. Experimental evidence as afforded by positive rays then receives attention, after which the sizes of atoms, the ionising potentials, and related properties, are dealt with. The combination of atoms to form molecules is then examined beginning with the simplest case of the union of two similar atoms each containing one electron and proceeding to a consideration of 4 electron atoms, polar molecules for which a physical test is described, *viz.* the determination of the specific inductive capacity of the substances formed by the molecules, the arrangement of electrons in octets, and the disposition of the electrons in such typical compounds as chlorides, oxides, carbonates, nitrates, sulphates, perchlorates, sulphites, chlorates, and nitrites. This serves as a preface to the discussion of the connection between chemical constitution and chemical properties in which residual affinity, molecular compounds and Werner's coordination numbers are reviewed. The mechanism of chemical combination is then dealt with, starting from the gaseous standpoint. Here something more than collisions between the molecules of the reacting gases is required from the fact that gases like H and O, H and Cl (in the dark), which can form very stable compounds, may be mixed without any appreciable amount of chemical combination taking place at moderate temperatures. This leads to the conception of the double layer and to active molecules, following which Thiele's theory of partial valencies, keto-enol change, production of light by chemical change, homologous elements, and variable valency are treated. Considerable attention is devoted to oxygen, the only gas known to be paramagnetic, and NO, the only compound of oxygen into which the magnetic properties are carried. Such a circumstance suggests that the magnetic quality does not arise from something intrinsic to the atom, but from some speciality in the arrangement of the colligating electrons in those molecules where it exhibits its magnetic character. This arrangement is now considered, and it is opined on analogy that if NCl or NF existed they would be magnetic. The diamagnetic properties of chemical compounds are next employed to test any theory of the distribution of electrons among the atoms of a compound; and a relation is found between the diamagnetism of a compound and of its constituents. The final topic of the series is the electron theory of solids, in which the author examines how atoms can be bound together not merely in twos or threes to form molecules but in large numbers so as to form solids; and the physical properties of such collections are considered. The sub-sections under this heading include the compressibility of metals and of the diamond, surface tension, communication of a charge from gaseous ions to the electrodes, intermetallic compounds, and mixed crystals. The whole series of lectures is in the usual clear and illuminating style of their distinguished author. H. H. Ho.

2089. *Is there an Element of Zero Atomic Number?* **F. H. Loring.** (Chem. News, 126. pp. 371-372, June 15, 1923.)—This is a continuation of the author's paper [Abstract 1524 (1923)], and calls attention to remarks by E. Rutherford, Eddington, and J. J. Thomson bearing on the subject. H. N. A.

2090. *Electrical Moments of Atoms and Molecules.* **R. D. Kleeman.** (Science, 57. pp. 747–748, June 29, 1923.)—If the interaction of atoms and molecules can be regarded as the interaction of electrical doublets, it becomes important to determine the moments of the systems involved. The quantity most nearly related is the internal heat of evaporation, and this is so complicated by heat agitation of the molecules that all quantities used have to be extrapolated to the absolute zero. In the case of the hydrogen atom, the effective length between the charges appears to be $2 \cdot 09 \times 10^{-10}$ cm. while the radius of the Bohr orbit is $5 \cdot 3 \times 10^{-9}$ cm. Hence, in the systems in which the hydrogen atom behaves as a doublet, the nucleus either lies slightly out of the plane of the orbit or the orbit is elliptic with the nucleus at one focus. A. Wh.

2091. *Spectra of Isotopes.* **P. Das.** (Calcutta Math. Soc., Bull. 13. pp. 183–190, March, 1923.)—Isotopes have the same atomic number and same arrangement of electrons, but different nuclear mass. Consequently the optical spectra should be affected only through the variation of the correction for the finite mass of the nucleus. This is usually applied by considering N, the Rydberg constant, to vary slightly; it is thus possible to calculate the separation to be expected between homologous lines of isotopes. Merton has found the separation for ordinary lead and radioactive lead to be about 100–200 times as large as is expected. McLennan has found for lithium isotopes a separation three or four times as large as is expected, and generalised that the separation must for any element be atomic number times as large as the theoretical value. Ehrenfest [Abstract 2288 (1922)] points out that the error arises through applying two-body results to an *n*-body problem.

The author assumes that, to a first approximation, the electrons can be treated separately; he arrives at an expression $\nu_1 - \nu_2 = \mathrm{N}m\left(\frac{1}{\mathrm{M}_1} - \frac{1}{\mathrm{M}_2}\right)\mathrm{R}_\infty\left(\frac{1}{p^2} - \frac{1}{p^2}\right)$ where M_1 and M_2 are the two atomic weights, which implies a separation N times as large as Bohr's formula. As a further test, the modified Rydberg constant was inserted into the Hicks formula, and applied to the sharp singlet series of helium. It was then found that better agreement was obtained. A. C. M.

2092. *Crystal Structures of the Cubic Forms of Arsenious and Antimonious Oxides.* **R. M. Bozorth.** (Am. Chem. Soc., J. 45. pp. 1621–1627, July, 1923.)—Determination of the crystal structures of arsenious and antimonious oxides by means of Laue photographs and spectral photographs shows that the crystals may be regarded as composed of As_4O_6 and Sb_4O_6 molecules having a diamond arrangement, each molecule corresponding with one carbon atom. The sizes of the unit cubes containing eight molecules of As_4O_6 or Sb_4O_6 are 11·06 Å. and 11·14 Å. respectively. The shortest distance between arsenic and oxygen atoms is 2·01 Å. and between antimony and oxygen atoms is 2·22 Å. The arrangement of the atoms within the molecule is the same as that of the carbon and nitrogen atoms in hexamethylenetetramine [Abstract 642 (1923)]. T. H. P.

2093. *Structure of Molybdenite.* **R. G. Dickenson** and **L. Pauling.** (Am. Chem. Soc., J. 45. pp. 1466–1471, June, 1923.)—Molybdenite is readily non-elastically deformable, and care has to be taken in the manipulation of the specimens for Röntgen-ray analysis. The structure is somewhat complex and a complete analysis is given. There are two MoS_2 groups in a hexagonal unit of length 12·30 Å.U. and an axial ratio 3·90. The molybdenum atoms are at $\left(\frac{121}{334}\right)\left(\frac{213}{334}\right)$ and the sulphur atoms at $\left(\frac{12}{33}u\right)\left(\frac{21}{33}u\right)\left(\frac{121}{332}-u\right)\left(\frac{211}{332}+u\right)$ where $u = 0{\cdot}621 \pm 0{\cdot}004$. A. Wh.

2094. *Crystal Structures of Alkali Poly-Halides.* **G. L. Clark.** (Nat. Acad. Sci., Proc. 9. pp. 117–122, April, 1923.)—A description is given of an X-ray analysis of such compounds as CsI_3, CsI_5, $CsIBr_2$, $CsBrI_2$, $CsICl_2$, CsIBrCl, etc., alkali tri-halides of varying degrees of stability.
A. B. W.

2095. *The Crystal Structure of Various Heusler Alloys by the Use of X-Rays.* **J. F. T. Young.** (Phil. Mag. 46. pp. 291–305, Aug., 1923.)—These alloys of Al, Mn, and Cu have ferromagnetic properties, and different theories have been proposed to account for this; in an attempt to distinguish between these theories, and to find some phenomenon which would show a positive variation with magnetic properties, a systematic crystal analysis of definite alloys in different conditions was undertaken, using X-ray methods; the three constituent elements were also investigated. One alloy was composed of face-centred cubic crystals, with constant 3·70 Å.U., and the other was a combination of the same crystals with body-centred cubic crystals, with constant 2·98 Å.U. It is thought that the alloys can be considered as being solid solutions of manganese-aluminium alloy in copper, though this conclusion is tentative. In no case was there any indication of the free constituent metals in the alloys. In agreement with the crystallographic data of iron, nickel, cobalt, and iron-nickel the more ferromagnetic Heusler alloy contained a body-centred cubic lattice. The variation of magnetic properties by heat treatment produced no apparent change in crystal form, and the same was true of the superposition of a magnetic field of 3500 gauss. The evidence, to date, points to the probable seat of magnetic phenomena in the behaviour and configuration of the outer or valence electrons. This is in agreement with the well-known changes in magnetic properties that take place as the result of chemical action, and those due to temperature variation, which may be expected to have a direct influence on the loosely bound valence electrons.
H. N. A.

2096. *Ether and Electrons.* **O. Lodge.** (Nature, 112. pp. 185–192, Aug. 4, 1923. Supplement.)—After a survey of past and present knowledge of the ether and the electric theory of matter the problem of radiation and matter is attacked. The source of radiation is always something material. Light can only emanate from an accelerated electron. Hence, at that end, the pressure of light (equal to energy per unit volume) has a material basis. But what happens at the other end? When it encounters matter, the reaction is exerted on matter, and everything is plain sailing. But while it is advancing in free ether, what is it that sustains the reaction? We can only answer—the wave-front. The wave-front cannot sustain it statically. It can only do so by advancing at the speed of light. The electron generates light. Does light generate an electron? The term light is here to include X-rays and all other forms of short-wave radiation

The density of sunlight near the earth is equivalent to 2×10^{-15} gramme per second per sq. cm. And a beam of this, ten centimetres square and supposed to be all converted or interpreted as matter, would generate about a tenth of a milligram in seventeen years. But the whole earth would catch 80,000 tons of it per annum. E. H. B.

2097. *Principle of the Quantum Theory.* **E. Persico.** (Elletrotecnica, 10. pp. 432–436, July 5, 1923.)—This paper gives a general account, more or less of a mathematical nature of the quantum theory under the following heads. The postulate of Sommerfeld; the radiation of a black body and specific heat; the atom of hydrogen and its spectrum; potentials of ionisation; theory of atomic structure; other phenomena. A. E. G.

2098. *The Present Position of the General Relativity Theory.* **G. W. de Tunzelman.** (Electrician, 91. pp. 112–114, Aug. 3, 1923.)—A review of the subject. W. R. C.

2099. *Mechanical Forces Indicated by Relativity in Electromagnetic Field.* **A. McAulay.** (Phil. Mag. 46. pp. 156–162, July, 1923.)—From the further development of equations obtained in "Multenions and Differential Invariants," III, the author arrives at the conclusion that: "A *perfectly arbitrary* invariant function occurring as the field terms in W (action per unit of four-dimensional volume), a quite definite force per unit volume (from which the arbitrary function has completely vanished) must exist." This result seems very surprising. Perhaps relativity will give similar guidance when elasticity, etc., has been brought under its treatment. G. W. DE T.

2100. *Poisson's and Green's Theorems in Riemann's n-Manifold.* **A. McAulay.** (Phil. Mag. 46. pp. 146–155, July, 1923.)—The author establishes the theorems corresponding to those of Green and Poisson for Riemann's *n*-manifold, either of space-like or space-time-like type, *i.e.* whether all the *n*-dimensions be real or $n - 1$ real and one imaginary. For the notation the author refers to his papers "Multenions and Differential Invariants," I, II, III; I and II in Roy. Soc., Proc. 99. p. 292, 1921, and 102. p. 210, 1922. III is not yet published.

G. W. DE T.

2101. *Deflection of Light in Passing through the Sun's Gravitational Field.* **W. W. Campbell and R. Trumpler.** (Lick Observat., Bull. 11. No. 346. pp. 41–54, 1923.)—From the mean of four plates, the authors find the deflection at the sun's limb as $1''\cdot 72 \pm 0''\cdot 11$. The observations give no evidence of any star displacement other than that radially away from the sun's centre. They examine the residuals of the check stars for any systematic errors that might affect the observed light deflections, and arrange the check stars according to their distance from the plate centre, giving a table of the group means of radial components of the residuals. The corrections based on these are applied with opposite sign to the observed radial displacements of the eclipse stars, and the deflection at the sun's limb is then found to be, not $1''\cdot 72 + 0''\cdot 11$ but $2''\cdot 05$. The authors give six sources of error which enter into this problem which consists in comparing by accurate measurements a photograph of the stars surrounding the eclipsed sun with a photograph of the same stars taken a night several months before or after the eclipse, when the sun is in another part of the sky. They consider that sources 1, 2, and 3 may be the cause of the observed deviations of the check stars among themselves, namely, distortion due to the optical parts of the instruments, disturbing effect of the uneven illumination of the background, and systematic distortion of the photographic film in the process of drying. Sources 4 and 5, they do not find effective, namely, abnormal refraction in the earth's atmosphere due to the passing shadow, or refraction in an extended solar atmosphere. But the excess of 17 % over Einstein's predicted deflection may represent the sixth source of error, namely, Courvoisier's "yearly refraction" in the immediate neighbourhood of the sun. This phenomenon consists of the apparent displacement of the stars away from the sun, but this displacement extends to large angular distances, and no physical explanation of the "yearly refraction" has been given as yet, nor is its amount in the immediate neighbourhood of the sun, known. The results in this paper are from the photographs taken in the 15-foot cameras; the investigation of the photographs taken with the 5-foot cameras has not yet been completed. [See Abstract 1778 (1923).] A. S. D. M.

2102. *Gravity, the "Sama" Condition of Matter, as the Cause of the Decrease of Temperature in a Vertical Atmospheric Column, and Similar Phenomena.* **G. Jäger** (Zeits. f. Physik, 17. 1. pp. 79–81, 1923), **R. v. Dallwitz-Wegner** (*ibid.* 17. 1. pp. 82–83, 1923), and **L. Weickmann** (*ibid.* 17. 3. p. 251, 1923.)—The attention of the author of a previous paper on this subject [see Abstract 1785 (1923)] is drawn to the work of Loschmidt and Boltzmann, and it is pointed out that Dallwitz-Wegner's conclusions contained in that paper are incorrect, and that if attention be paid to the Maxwellian distribution of velocities amongst the molecules of gas, it can readily be shown that the temperature distribution is independent of any external force. In reply, **Dallwitz-Wegner** contends that the distribution of velocities amongst the molecules does not affect his argument, which is in accord with the principle of the conservation of energy. The "sama" condition is illustrated by the consideration of the expansion and subsequent deposition of water-vapour in a cylinder. **Weickmann** refers to the prior work of Bjerknes on this subject and points out an error made by Dallwitz-Wegner in his application of the energy principle. J. S. G. T.

2103. *Possible Nature of the Corpuscular Radiation which Causes the Polar Aurora.* **H. Bongards.** (Phys. Zeits. 24. pp. 279–285, July 1, 1923.) —Slipher found for the wave-length of a green line discovered by Wiechert in the night sky of middle latitudes the wave-length 5578·05 Å., while Vegard found $\lambda = 5578 \cdot 2 \pm 1$ for what is generally regarded as the same line in the aurora. A faint line in the multiple line spectrum of hydrogen, $\lambda = 5578 \cdot 3$, can hardly be identified with this; and the only other known line of the right wave-length is $\lambda = 5577 \cdot 98$ in the blue spectrum of argon. There are many other lines in this spectrum and in that of the aurora; but so far the latter has not been measured with sufficient accuracy to allow of identification, as the number in both cases is so large at the violet end of the spectrum; but there is additional evidence in the fact that in the red portions of the aurora Vogel found two bright lines $\lambda = 6297$ and $\lambda = 5189$; these measurements were taken in 1871, and are regarded as fairly accurate. In the red argon spectrum, which appears to be due to argon atoms which have lost one electron, Paschen found a bright line, $\lambda = 6297 \cdot 15$, and Kayser another, $\lambda = 5188 \cdot 46$; these are probably identical with the above auroral lines. In spite of its high density, argon may be present normally in the atmosphere at heights above 100 km. where the aurora is seen; volcanic eruptions may carry this gas to great heights, and the thermodynamical properties of monatomic gases favour their remaining at high elevations when they have attained them; the author, however, favours the view that argon particles are ejected from the sun, with very high velocities, and entering the earth's atmosphere produce the aurora. There are difficulties in the way of this theory. The absence of Doppler effect indicates a velocity less than 3×10^7 cm., which would not enable the particles to penetrate so deep into the atmosphere; the argon particles may leave the sun strongly positively charged, with a very high velocity, and being devoid of the electrons which are concerned in radiation do not begin to emit light until, by collisions with the atoms of the air, they have lost much of their velocity, and picked up the necessary electrons. The original paper should be consulted for the author's speculations on the source of the argon in the sun, and the possible effect of different isotopes of argon on the phenomena observed. H. N. A.

2104. *Spectrum of Aurora Borealis and Upper Layers of the Atmosphere.* **L. Vegard.** (Comptes Rendus, 176. pp. 947–950, April 3, 1923.)—A table of wave-lengths is given of the aurora (obtained from three forms of spectrograph) compared with the spectrum of nitrogen. Most of the auroral rays can be identified with those of nitrogen, but the green ray, 5578·4, and three others are not in the table of nitrogen lines determined in the laboratory and cannot be attributed to H, He, or O. Even on over-exposed spectrograms of the aurora no trace of hydrogen or helium can be found, and moreover in the laboratory the kathode rays in the mixtures (N — H) and (N — He) have been investigated, showing that the pressure of atmospheric nitrogen at a height between 100 km. and 120 km. is greater than the pressure of H and He, which therefore cannot form an atmospheric layer at such heights. The green auroral ray is found at both the upper and lower borders and must be emitted by some gas having the same molecular weight and pressure as nitrogen, and it is inferred that the entire auroral spectrum is due to nitrogen. The author explains the fact that the auroral light is sometimes visible at heights of 500–600 km., to the strong ionisation of the upper layers by the X and gamma rays from the sun. A. S. D. M.

2105. *Auroral Spectrum and Upper Strata of Atmosphere.* **L. Vegard.** (Phil. Mag. 46. pp. 193–211, July, 1923.)—[For the first part of this paper, see preceding Abstract.] Table III shows that the auroral spectrum is almost entirely due to nitrogen, partly to the negative, partly to the positive band spectrum. The aurora is principally emitted at 100–120 km., the top of the streamers extending upward to 500–600 km.; and the most prominent line throughout the whole extent is the green line, $\lambda = 5578 \cdot 2$, so that the unknown gas which emits it, must dominate the atmosphere throughout these layers, that is from a height of 100 km. to the boundary. The author shows that this line cannot be attributed to H or He, and he considers in this connection the density and temperature found by Lindemann and Dobson in the upper atmosphere. [See Abstracts 1069 and 1788 (1923).] Therefore he concludes that neither H, nor He, nor some light unknown gas (geocoronium), but nitrogen must be the predominant constituent of the atmosphere out to its boundary. The simplest solution is to suppose that the upper strata are electrically charged, and that a highly ionised upper layer exists, the charge being attached to clusters or small crystals of nitrogen. [See next abstract.] As long as the cosmic rays are absorbed in this layer, the typical green line is shown, and therefore this positive layer must come as low as 100 km. If the negatively charged cosmic rays penetrate to the neutral atmosphere, the nitrogen spectrum will revert to an ordinary type, and the green line will disappear. As a change of spectrum involves change of colour, the author suggests that the coloured borders to auroræ should show where the neutral atmosphere begins. The coloured auroral streamers may be due to intense ray bundles of negative electrons, neutralising the positively charged lays through which they penetrate. **A. S. D. M.**

2106. *Constitution of the Upper Layers of the Atmosphere.* **L. Vegard.** (Comptes Rendus, 176. pp. 1488–1491, May 22, 1923.)—[See preceding abstracts.] Numerical computations of the order of magnitude of the electrical charges lead to the conclusion that nitrogen at the extreme limit of the atmosphere cannot exist as a gas, but is condensed into small particles. If the temperature is below 60° absolute, nitrogen is probably solidified in the form of small crystals, and this fine nitrogen dust is electrically charged by means of the solar photoelectric radiation. The auroral spectrum is emitted when these small nitrogen crystals are exposed to electric rays, and the number of auroral spectral lines is so reduced that the lines of gaseous nitrogen are not produced. The altitude of the atmosphere is supposed to increase from the poles to the equator, partly because of the greater solar activity there, partly because the charged particles follow the lines of magnetic force; the nitrogen dust tends to accumulate round the plane of the magnetic equator. Störmer has established that the height of auroral rays in lower latitudes is greater than in high, indicating that the atmosphere is of greater extent at the equator. This dust atmosphere scatters the sun's light and explains the blue colour of the sky, and to this nitrogen belt the author attributes also the zodiacal light; and to the electric charge of the upper strata, that the night sky almost always shows the green line. **Errata** (*ibid.* p. 1772, June 11, 1923). **A. S. D. M.**

2107. *British Upper-Air Data in the Light of the Norwegian Theory of the Structure of the Cyclone.* **W. H. Dines** and **L. H. G. Dines.** (Roy. Meteorolog. Soc., J. 49. pp. 167–173; Disc., 173–176, July, 1923.)—A large number of ascents with sounding balloons in the British Isles have been considered, and 16 selected as made on days when a well-marked polar front appeared on the synoptic charts and the ascents occurred in the cold sector. The lapse rates in these ascents have been compared with those obtained from two other groups, each of 20 ascents, selected at random, to see if any evidence of the presence of a warm current over a cold one could be found. The criterion used to determine a discontinuity was the occurrence of an inversion of temperature. The lapse rate curves show that with high pressure a discontinuity of temperature is found frequently, but only rarely with low pressure. A series of kite ascents made at Pyrton Hill have also been considered to see if different currents could be detected from the variation of humidity. These show that temperature inversions in the lower layers are generally associated with a decrease of humidity on ascent. Several special cases give results in favour of the Bjerknes theory, but in general no conclusive evidence is found. A. W. L.

2108. *The Connection between Pressure and Temperature in the Upper Layers of the Atmosphere.* **W. H. Dines.** (Monthly Weather Rev. 50. pp. 638–642, Dec., 1922.)—Examples of the correlation coefficients between pressure and temperature in the upper atmosphere are given, and the physical significance of this connection is discussed. The observed facts may be explained by assuming that any changes in the air are adiabatic, and that vertical motion occurs. The time required for motions of this type is not large enough for departure from adiabatic conditions due to the effects of radiation to be important, but it is suggested that in some cases the effects of eddy viscosity may be considerable. A. W. L.

2109. *Theory of Measurement of Wind by Shooting Spheres Upwards.* **L. F. Richardson.** (Roy. Soc., Phil. Trans. 223. pp. 345–382, July 16, 1923.)—In order to obtain wind speeds at various heights, steel balls are shot from a gun making a small angle with the vertical, the angle being chosen by trial so that the ball falls practically at the point of projection. Varying charges of explosive give varying times of flight, and from the "balancing tilts" and the times, it is possible to obtain wind speed and direction at all levels, up to the greatest height the shot can reach. The present paper contains the mathematics of the flight, and shows how the observations are to be treated to give the results sought. W. G. B.

2110. *The Diurnal Variation of Winds for Different Coastal Stations of Japan.* **T. Terada** and **T. Kobayasi.** (Aeronaut. Research Inst. Imp. Univ. Tôkyô, Report, 1. pp. 35–85, July, 1922. In English.)—The diurnal change in the frequency of winds for a number of widely distributed coastal stations in Japan is investigated, the velocity of the winds being neglected. It is shown that, if the deviations of the actual winds from the normal are not too small, the resultant frequency varies approximately as the mean wind, and consequently the diurnal variation of wind may be approximately represented by that of the frequency resultant. The data considered are taken from 14 stations for the eight years 1899–1906, at each even hour of the day, during April, August, and December. The North and East components of the resultant frequency are computed for each hour, from which the mean monthly frequencies are obtained. The diurnal variation of resultant frequency, for each station during each month considered, is shown in a series of curves, and may be classified into the following types: (1) Where diurnal variation of a simple harmonic type is predominant. (2) Where the prevailing influence is topographic. (3) Where a conspicuous semi-diurnal component is shown in a direction perpendicular to the diurnal one.

The daily mean of the vectors corresponding with the two-hourly resultant frequencies, may be regarded as a characteristic of the general wind of the season; this seasonal part is more conspicuous in December than in April or August. Further diagrams for each station show a straight line representing the seasonal part of the wind, and two concentric ellipses representing the diurnal and semi-diurnal components, respectively. When the area of the ellipse is large, the seasonal part is not conspicuous. If the diurnal ellipses are arranged on a map of Japan their major axes lie almost perpendicular to the coast-line, thus showing the importance of local land and sea breezes. An attempt to separate the regional influences, common to a number of stations, from purely local effects, suggests that convection plays a large part in the cause of the regional component. A. W. L.

2111. *Kinetic Theory of Non-Uniform Rarefied Gas and the Escape of Atmospheric Molecules.* **J. E. Jones.** (Cambridge Phil. Soc., Trans. 22. pp. 535–556, June, 1923.)—The theory of the escape of molecules from the atmosphere as developed by Jeans and Milne is not wholly satisfactory. In the first case it leads to illogical results, while in the second it involves the assumption that all molecules except the one under consideration are at rest. The paper gives a more exact analysis by investigating the conditions for a gas in which the free paths of the molecules are functions not only of their molecular velocities but also of direction and position. The conditions of escape are four: (i) The last collision must be above a certain critical height, (ii) the direction must lie with "a cone of escape" of which the angle is a function of the position of its vertex, (iii) the velocity must be sufficient to overcome the gravitational potential, and (iv) the velocity must be high enough to avoid further collision. This critical velocity is also a function of direction and position. The cases of simple and mixed isothermal atmospheres are discussed. In both the loss is slower than indicated by Jeans' theory, and hence Jeans' conclusion as to the constitution of planetary atmospheres are unaffected. A. Wh.

2112. *Effect of Steady Wind on Sea-Level near a Straight Shore.* **H. Jeffreys.** (Phil. Mag. 46. pp. 114–125, July, 1923.)—It is well known that in any steady atmospheric motion, the wind is along the isobars and perpendicular to the horizontal thrust on it, the higher pressure being on the right in the northern hemisphere, on the left in the southern. The same proposition, subject to the same conditions must hold in the ocean, and it has been shown [see Abstract 1045 (1920)] that a closely related result holds for ocean currents driven by friction of the wind blowing over the water surface; the water drift, when unobstructed, is perpendicular to the wind. The surface current, however, is inclined to the wind towards the high-pressure side, and, provided the eddy viscosity be uniform down to a specifiable depth, the inclination is 45°. F. J. W. Whipple pointed out to the author that this must be modified when the motion is obstructed by a long straight coast, which prevents any resultant drift from taking place across a vertical section parallel to the coast. The modifications required are here discussed. It is found that the ultimate effect of a steady wind is to produce an inclination of the water surface, the contour lines being parallel to the coast. The resultant drift in any vertical column is also parallel to the coast, but the amounts of the slope and the drift depend on the wind velocity, the depth, and the eddy viscosity. In such a steady motion obstructed by a shore, the curent at the surface is not in general at 45° to the wind. The complexity of the formulæ resulting from the analysis is so great that special cases have to be separately worked out. It is found that in shallow water the maximum slope is produced by a wind at right angles to the shore, and no slope by a wind parallel to the shore. In deep water the action is the exact converse. The time required to convert open ocean conditions into a state of steady motion obstructed by a shore will be a fraction of a day for places within 200 km. of the coast. For greater distances the time will vary as the squared distance. In general a steady motion in a confined sea will be established within a day of the wind beginning. In the motion of water in an open ocean under the influence of a cyclone or large seasonal depression or elevation, the drift will be at right angles to the wind, towards the high-pressure side, so lowering the water surface within the cyclone. The conditions are, in general, those of light winds over deep water, the surface current being at 45° to the wind in the early stages, gradually becoming more nearly along the isobars. For a cyclone with light winds and horizontal dimensions large compared with 400 km., the time for the change will be about 3 to 4 days; for a hurricane a few hours; for a disturbance of horizontal dimensions large compared with 4000 km., a few months. Hence in seasonal disturbances in the Pacific and Atlantic the surface current should be at approximately 45° to the wind. G. W. DE T.

2113. *Meteorological Observations for the Year* 1919. (Boletim Meteorologico [152 pp.], 1922.)—Refers mainly to Rio de Janeiro.

2114. *Haloes of Abnormal Radii.* **L. Besson.** (Monthly Weather Rev. 51. pp. 254–255, May, 1923.)—The author sets out to explain the occurrence of unusual halos by taking the observed values of their radii, and deducing from these the most likely value for the inclination of the faces of the crystal which produces them. The halos of van Buijsen, Rankin, and Burney, are produced by crystals with an inclination around 25°, the most probable value being suggested as 25° 14·4′. The halo of Dutheil may be caused by refraction between, either the base and an oblique face of the crystal, or a prismatic and an oblique face. The probable value of the radius of the halo of Scheiner is given as 27° 45′, and seven possible methods by which it might be produced are given. A. W. L.

2115. *A New Form of Thermoelectric Recording Pyrheliometer.* **H. H. Kimball and H. E. Hobbs.** (Monthly Weather Rev. 51. pp. 239–242, May, 1923.)—A thermoelectric recording pyrheliometer is described, which, when exposed to full sunshine, is capable of developing about 15 millivolts. A thermopile of 50 couples is made from a combination of the alloys 60 Au–40 Pd and 90 Pt–10 Rh by electrically fusing the wires. Alternate junctions are attached to, but electrically insulated from, two thin concentric copper rings; the upper surface of the inner ring is painted black, and that of the outer ring white. When solar radiation falls on the rings the voltage produced by the excess of temperature of the junctions attached to the blackened ring, over those attached to the white, is very nearly proportional to the intensity of the radiation. A continuous record is obtained by using an Engelhard recording voltmeter.

A sample record shows results obtained with two separate thermopiles; one is mounted in a diaphragmed tube and used to measure the direct solar radiation, while the other is exposed horizontally under a glass cover to the total radiation from the sun and sky. With a solar radiation intensity of 1 gramme calorie per minute per sq. cm. of surface the voltage set up is between 9 and 10 millivolts. Comparison of the results obtained with the readings of a Marvin pyrheliometer shows variations of about

5 %. The variation is stated to have been due to distortion of the record caused by imperfections in the glass cover, and to have become less when this was remedied. A. W. L.

2116. *Values of the Solar Constant*, 1920–1922. **C. G. Abbot and Colleagues.** (Monthly Weather Rev. 51. pp. 71–81, Feb., 1923.)—The present paper gives determinations of the solar constant made at Mount Harqua Hala, near Wenden, Ariz., and at Montezuma, Chile. The construction of the former station is described, and the systematic errors of the observations are discussed; the principal corrections are: (1) That depending on humidity. (2) A small systematic horizontal increase to the Harqua Hala values to bring them up to the scale at Montezuma. The tabulated results for both stations show the probable accidental error at one station as 0·41 % of the solar constant.

Prevailingly high values of the solar constant are shown at both stations for the periods: Nov. 1–18, 1920; Jan. 8–16, Feb. 11–March 4, April 1–17, and Nov. 17–Dec. 10, 1921; Jan. 15–19, and Feb. 12–22, 1922. The low periods are: June 4–13, and Oct. 8–22, 1921; Jan. 4–12, and March 1–Sept. 30, 1922. A striking decrease is shown in the solar radiation from Nov., 1921, to the close of the period under discussion in September, 1922. A. W. L.

2117. *Solar Activity and Atmospheric Electricity.* **L. A. Bauer.** (Nature, 112. pp. 203–205, Aug. 11, 1923.)—In reply to Chree's paper [Abstract 1637 (1923)], it is suggested that Kew is an unfavourable station for these investigations for two reasons: (1) Because c_2/c_1, the ratio of the amplitudes of the 12-hour and the 24-hour waves, is large; (2) because the value of the potential gradient is large. The type of formula representing the relationship between potential gradient and sunspot number is: $P = P_m + s(S - S_m) + t(T - T_m)$, in which P_m is the mean value of P, T_m the mean date, and S_m the mean annual sunspot number. The coefficients s and t represent the change in P due to one sunspot number, and the annual change, respectively. Tabulated values of the quantities in the formula are given for Kew, Eskdalemuir, and Ebro. The correlation coefficients obtained between the potential gradient and sunspot number are 0·94 for Ebro, 0·77 for Kew, and 0·90 for Eskdalemuir. For locally undisturbed stations the relationship between sunspot activity and atmospheric electricity is as definite, and the variations thus caused are as great, as between sunspot activity and terrestrial magnetism. It is also concluded that an increase in the sunspot number corresponds with a decrease in the intensity of magnetisation of the earth. The potential gradient is subject to an annual or secular change which may vary in magnitude or sign. A. W. L.

2118. *Solar Activity and Atmospheric Electricity.* **C. Chree.** (Nature, 112. pp. 361–362, Sept. 8, 1923.)—The criticisms of the Kew data made by Bauer [see preceding Abstract] are refuted for the following reasons: (1) To take c_2/c_1 as a sign of inferiority is not consistent with the fact that the ratio is highest at Kew in summer, when the potential gradient is lowest. (2) The mean potential gradient at Eskdalemuir is nearer to the Kew than to the Ebro value; consequently, if Kew is inferior because of a high value, Eskdalemuir should also be inferior. Of the three stations referred to the author would expect Kew to be the least affected by accidental irregularities. If, as Bauer suggests, an increase in sunspots is accompanied by a decrease in the intensity of magnetisation of the earth, there should be an 11-year period in the secular change; this has not been established. A. W. L.

2119. *Distribution Law of Stellar Velocities.* **W. J. Luyten.** (Nat. Acad. Sci., Proc. 9. pp. 191–194, June, 1923.)—In the mathematical theory of stellar statistics an analytical expression for the distribution of cosmic velocities is needed. The well-known Maxwellian form of this "velocity law," which assumes a random distribution in direction, has been shown by Kapteyn and others not to agree with observation. The only method of verifying any assumed law is to analyse the motion of all the stars in a given volume of space; and this the writer attempts to do by taking a sphere with the sun as centre and a radius of 10 parsecs, and by tabulating the velocities of all stars definitely known to lie within this sphere. He shows that the addition of stars within this distance whose parallaxes are at present unknown is not likely to have much effect on the result. His conclusion is that the distribution of stellar velocities can most probably be represented by a single logarithmic curve instead of by a combination of two Maxwellian curves or two logarithmic error curves. M. A. E.

2120. *Velocity Curves of Spectroscopic Binaries.* **H. D. Curtis.** (Nat. Acad. Sci., Proc. 9. pp. 187–191, June, 1923.)—The spectrographic velocity curves of several Cepheid variable stars, and of a few other stars not yet known to be variable, show puzzling deviations from simple elliptical orbital motion. These deviations have hitherto been explained by superposing upon the primary curve a secondary oscillation exactly one-half or one-third the period of the primary. A new method is now suggested which represents the observations by means of a purely elliptical velocity curve plus a "hump," and six curves are given representing the motions of six different stars. All the "humps" occur close to the time of the star's observed maximum velocity of approach towards us, which is also the time of maximum brightness; and it is suggested that these curves support Duncan's theory of a "brushing back" of a bright star's atmosphere from its advancing face during its motion round a dark star through a slightly resisting medium. This would be most noticeable when the star is coming directly toward us, and the calculated effective depths to which the atmosphere is driven back in different cases, *viz.* from 500,000 km. to 10,000,000 km. is not unreasonable if the stars are assumed to be large and tenuous, some as large as Betelgeuse. M. A. E.

2121. *Parallaxes of Stars Determined from Spectral Class and Proper Motion.* **W. J. Luyten.** (Lick Observat., Bull. 11. No. 345. pp. 33–40, 1923.)

2122. *Spectroscopic Parallaxes of the B-Type Stars.* **W. S. Adams** and **A. H. Joy.** (Mt. Wilson Observat. Contrib. No. 262. Astrophys. J. 57. pp. 294–307, June, 1923.)—The correlation between spectral type and absolute magnitude which has given us individual parallaxes of the A-type stars has now been extended to stars of O8 to B9, and a comparison of the results with trigonometric parallaxes and parallaxes derived from moving clusters shows a satisfactory degree of accordance. A detailed list is given of 300 stars. The principal uncertainties occur in O-type stars, and in the early B-type with sharp and with diffuse lines, this difference seeming to indicate a difference in absolute magnitude. M. A. E.

2123. *Internal Motions in Spiral Nebulæ.* **A. van Maanen.** (Mt. Wilson Observat. Contrib. No. 260. Astrophys. J. 57. pp. 264–278, June, 1923.)—Photographs of the spiral nebula M33, taken in 1910 and 1922, have been measured, comparing the positions of 400 points in the nebula with 24 stars. Tables of these measures are given, and a plate on which the motions are plotted. Work on this and six other nebulæ definitely show an internal motion, which is either rotatory or outward along the arms of the spiral. It is here shown that the displacements observed cannot be due to errors of instrument or measurement, and similar motions have been found in another spiral nebula by three other observers with three different instruments.

An approximate estimate of the parallax of M33 has been obtained by comparing the radial and the tangential velocity in a bright condensation; and a mean parallax for spiral nebulæ has been found by comparing the mean radial and tangential velocities of a large number of these objects. Also by Jeans' theory the actual distances apart of the condensation on the arms of nebulæ can be predicted, and comparing these with the observed apparent distances the size of a nebula, and hence its distance, can be found. All these results agree in indicating for the larger spirals parallaxes ranging from a few ten-thousandths to a few thousandths of a second of arc, and diameters ranging from a few to several hundred light-years. Hence the spiral nebulæ cannot be comparable in size with the Galaxy. M. A. E.

2124. *Proper Motions Measured with the Blink Microscope.* **R. T. A. Innes.** (Union Obs. S. Africa, Circ. No. 56. pp. 161–186, Sept. 12, 1922.)—Two Paris plates of the field at 18h. 35m. + 31° 10′, were measured first by C. Le Morvan in France, and secondly by R. T. A. Innes with the blink microscope. A further and independent investigation has been made of the same plates by J. Bosler with a blink microscope belonging to the Paris Conservatoire des Arts et Métiers, who says that it can be affirmed that with both Le Morvan and R. T. A. Innes, 68 % of the displacements are certainly not illusory.

The remainder of the Circular includes: observations of the Galilean satellites of Jupiter for 1922, January to August; micrometric observations of Comet 1922 *b* (Skjellerup); differential observations of Neptune, 1922, April to May; occultations, 1922, April to September; the choice of suitable objects among lunar craterlets for determination of the moon's place, Langrenus *m*, Triesnecker B, and Lohrmann A being suggested in addition to Mösting A; also reprints of seventeen Franklin-Adams charts. [See Abstracts 1965 (1922) and 859 (1923).] A. S. D. M.

2125. *Spiral Nebulæ.* **C. D. Perrine.** (Observatory, 46. pp. 272–279, Sept., 1923.)—The author agrees with Lindemann (Observatory, May, 1923) that the spiral nebulæ may have originated as clouds of dust particles expelled from the Galaxy by light-pressure, but considers that the known facts are against his hypothesis that they are still members of our stellar system, and composed entirely of cosmical matter shining by reflected light from the stars. It is suggested that they are stellar systems like the galactic but on a very small scale, and that they have developed into these while receding from the Galaxy so rapidly that they are now beyond its gravitational control. This suggestion is based on (1) the tendency of spiral nebulæ to exhibit very high positive radial velocities, and their absence from the Galaxy and crowding towards its poles, whither, the author states, they would chiefly be driven if acted upon by the total light-pressure of the Galaxy; (2) the resemblance of their spectra to the average star-spectrum of the galactic system, and the presence of small faint novæ and some nebulosity, both dark and bright; (3) the rapid motions outward which have been observed along the arms of some spirals, which indicate a much lesser size and distance than would be required for these objects if they were external galaxies of the same order as our own. For the few spirals that have been found to possess low velocities of approach, it is suggested that they have been turned back by some agency, or are escaping from another Galaxy; and it is possible that the study of spiral nebulæ may throw light on the existence of other galaxies, and on the length of time necessary for cosmical matter to develop into stellar systems. Globular clusters also seem to be practically autonomous systems, very small compared with the Galaxy, but they are usually approaching, and their distribution is totally different from that of the spiral nebulæ. M. A. E.

2126. *Stars with Large Proper Motions.* **W. J. Luyten.** (Lick Observat., Bull. 11. No. 344. pp. 1–32, 1923.)—A new catalogue of stars with proper motions exceeding 0″·50 annually has been compiled, in order to include all the new and more accurate material which has recently been obtained. The catalogue contains 749 stars, and a diagram shows the velocity and direction of each. The total number of stars with these high velocities, including the faintest, is roughly estimated at between three and four thousand. The relation between proper motion and absolute magnitude confirms the generally accepted theory of stellar evolution. The conclusion is reached that the mean absolute magnitude of all stars is lower than 7·7 m. New determinations of the apex and velocity of the sun's motion, and of the vertices of star streaming are made from this material. M. A. E.

2127. *The Proper Motions and Mean Parallax of the Cepheid Variables.* **R. E. Wilson.** (Astron. J. 35. pp. 35–44, May 24, 1923.)

2128. *The Proper Motions of* 315 *Red Stars.* **R. E. Wilson.** (Astron. J. 34. pp. 183–192, Jan. 20, 1923.)

2129. *Temperature of Stars.* **H. Dingle.** (Nature, 112. pp. 167–168, Aug. 4, 1923.)—Stellar spectra consist of two parts; the continuous spectrum is attributed to the hotter, deeper-lying part, the absorption lines to the cooler but still luminous atmosphere. These spectral divisions will give the characteristic temperatures of the two regions, the photosphere and the atmosphere. If stars resemble the sun, these will also possess coronæ outside the stellar atmospheres and cores within the photospheres, and we know nothing experimentally of the temperatures of these. Also in measuring temperatures, there are the difficulties, first of obtaining the data and next of interpreting them. The temperatures of the photospheres are deduced from the distribution of energy in the continuous spectra, but these measurements give no indication as to which region of the star they apply, and they are simply termed "effective" temperatures; but by a diagram the author shows that atmospheric and photospheric temperatures are of the same order of magnitude, and, without question, they give a true relative order of temperature arrangement. A. S. D. M.

2130. *Spectra of Double Stars.* **F. C. Leonard.** (Lick Observat., Bull. 10. No. 343. pp. 169–194, 1923.)—The author gives (1) a brief account of earlier investigations of this subject, (2) the apparatus and methods employed in observing the spectra of 80 double stars at Mt. Hamilton, (3) the method of classification of spectra, together with a table of typical stars of the various spectral classes, (4) the catalogue of the 80 double stars, with explanatory notes, (5) a list of 158 doubles observed elsewhere than Mt. Hamilton, for which accurate spectra have been published, (6) four diagrams of which Fig. 1 exhibits the spectral class of the secondary component as a function of the primary, and Fig. 3 gives the difference of spectral class of the secondary as a function of the difference of magnitude, (7) a list of 85 double stars with known spectra and parallaxes, Fig. 4 giving diagrammatically the spectral classes and absolute magnitudes of their components. The principal conclusions are: (*a*) In dwarfs, the primary is earlier than the secondary; in giants, the reverse holds good. (*b*) In both giants and dwarfs the absolute difference in spectral class is related to their disparity in magnitude. (*c*) The spectrum of each component of a binary seems to be a function mainly of its absolute magnitude, as is the case with stars in general. (*d*) The difference in spectral class between the components seems independent of their projected linear separation. (*e*) The less massive component will, in general, pass through its life-history in advance of the more massive component. A. S. D. M.

2131. *Effect of Astigmatism on Star Discs.* **A. Buxton.** (Roy. Astron. Soc., M.N. 83. pp. 475–480, June, 1923.)—An investigation of the distribution of light in the disc image of a star when there is astigmatism of the first type, *i.e.* the bundle of rays is symmetrical in both the sagittal and tangential planes. The intensity has been calculated for amounts of astigmatism equal respectively to twice and four times the tolerance of $\lambda/8$ on either side of the ideal focus for *f*/15. It is concluded that the presence of astigmatism detracts from the good quality of the image, and as the length of the astigmatic figure increases the disc image rapidly deteriorates. The resolution of double stars is adversely affected in the presence of astigmatism, even when the eye has chosen the disc image of smallest dimensions. J. W. T. W.

2132. *The Distribution of Stars of Spectral Class M.* **H. Shapley and Annie J. Cannon.** (Harvard Coll. Obs., Circ. No. 245. pp. 1–6, 1923.)

2133. *Distances of Two Hundred and Thirty-Three Southern Stars.* **H. Shapley and Adelaide Ames.** (Harvard Coll. Obs., Circ. No. 243. pp. 1–8, 1923.)

2134. *Distances of One Hundred and Sixteen Southern Stars.* **H. Shapley.** (Harvard Coll. Obs., Circ. No. 246. pp. 1–4, 1923.)

2135. *Observed Maxima and Minima of Variable Stars for 1922.* **L. Campbell.** (Harvard Coll. Obs., Circ. No. 244. pp. 1–8, 1923.)

LIGHT.

2136. *On a Combination of Reflectors.* **Marsat.** (Comptes Rendus, 177. pp. 37–39, July 2, 1923.)—This investigation is due to a French law that automobiles must have an apparatus capable of illuminating beyond 100 m., and this requires a flattened pencil of suitable dimensions, instead of the sensibly round one afforded by the usual paraboloid reflector. The required optical combination was obtained by placing the incandescent body in the form of a horizontal strip upon the axis of a parabolic reflector whose meridian curve is a parabolic arc having its focus upon the axis of revolution. The latter coincides with the horizontal focal line of a second cylindrical reflector which receives the light from the first reflector and also a certain amount direct from the luminous source. From this combination the required shape of pencil is obtained while the photometric intensity is very great. This method of combination may be generalised using other curves than the parabola. H. H. Ho.

2137. *A Chart of the Flicker Photometer.* **H. E. Ives.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 363–373, May, 1923.)—The writer first reproduces a diagram showing critical speeds for disappearance of flicker for various relative amounts of alternated red and green light. With the light sources now available it was possible to extend the range of this diagram. Three new sets of data are incorporated, (*a*) comparing critical frequency with illumination for various monochromatic radiations, (*b*) comparing critical speeds of disappearance of colour-flicker with speeds for the compared colours separately and (*c*) data embodied in the mathematical expression for critical speeds for various amplitudes of the fluctuating stimulus. These relations are illustrated by various diagrams. Finally the complete chart, giving a picture of the relations present in the flicker photometer for red and green light is presented. The chart shows the usual course of the flicker setting about the axis of the figure as the illumination is progressively increased. At the top of the chart, for very high illuminations, the median of the flicker region is on the red side, indicating that light of this colour will be underrated; at very low illuminations the setting point moves towards the green side, indicating that this colour will be underrated, in accordance with the "reversed Purkinje effect." But at a still lower illumination the flicker setting moves once more towards the red. J. S. D.

2138. *Physiological Limits to Accuracy of Visual Observation and Measurement.* **H. Hartridge.** (Phil. Mag. 46. pp. 49–79, July, 1923.)—Hitherto attention has been devoted chiefly to instrumental errors, mental bias of the observer, and probable accuracy of observations. A fourth factor requiring consideration is the physiological properties of the sense organ acting as a connecting link between the instrument and the brain. In this paper the *sense of sight* only is considered. Under ideal conditions the centres of two lines or dots must subtend at the eye an angle of approximately 60 seconds of arc in order that they shall be seen as two. If conditions are not ideal a much greater separation is needed. Formulæ giving the limit of useful magnifying power of optical instruments in general give too high values. Visual acuity for positions and movements of contours is nearly ten times greater than for the resolution of double points. The method of coincidences gives very accurate results and the eye-error is less than 10 seconds of arc. Blurred lines are set into coincidence with about the same accuracy as sharp lines; owing to ocular imperfections images of sharp lines are diffuse, so that the difference is not great. Coincidence methods of measurement are liable to various visual errors associated with (*a*) line thickness, (*b*) malfocus, (*c*) colour, (*d*) intensity of light, (*e*) visual threshold, and (*f*) non-coincidence of exit pupils. Means of avoiding these errors are described. The interpolation method of measurement (*e.g.* in the slide rule) is much less accurate than the coincidence method. The contact method of measurement (as used in the spider line micrometer eyepiece) is liable to error due to (*a*) irradiation and (*b*) contrast. Sizes of black objects are overestimated and sizes of white objects underestimated. The effect of varying illumination demands further investigation. Measurements of depth and distance, colour and intensity are also discussed and suggestions for the best type of "field" are made. J. S. D.

2139. *Geometric Progression in Optically Prepared Standards.* **A. P. Harrison.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 375–377, May, 1923.)—A series of 29 tubes was recently made from a solution of safranin, starting with a concentration just visible to the naked eye and terminating in a colour of definite strength (corresponding to 0·0031 % safranin). It was noticed that in order to make the tubes differ perceptibly it was necessary to increase the strengths of safranin in each subsequent tube by an increasingly large amount, apparently consisting in a geometric series of 29 items. The author presents a table showing values calculated by a geometric series and those determined by observation, which exhibit good agreement. The relationship has been verified for other colours, *e.g.* solutions of luteol, methyl orange, malachite green, and Bismarck brown. J. S. D.

2140. *Algebraic System of Optical Design.* **H. D. Taylor.** (Optical Soc., Trans. 24. 3. pp. 143–167, 1922–1923.)—The author considers that the recent tendency among optical designers to test the performance of optical designs by laborious ray tracings instead of by examination of the actual performance of the embodied idea involves a needless waste of time and money. Ray tracings do not give any indication of the direction in which changes are required, such as may be obtained from algebraic formulæ. Examples illustrative of the author's contention and of the method of application of the system he advocates are given in the paper. It is sometimes convenient to try out a proposed design on a scale model considerably larger than the system finally to be used. In the *discussion*, **F. J. Cheshire, T. Y. Baker, T. Smith, J. W. Hasselkus, J. Perry**, all considered that ray tracing was of great use and preferred to see it combined with other methods of checking design rather than excluded altogether. **L. C. Martin** and **J. S. Anderson** considered that the accuracy of measurement of aberrations of an actual system was an important factor in the application of the author's method. J. W. T. W.

2141. *Distribution of Corrective Duties in Optical Instruments.* **T. Smith.** (Optical Soc., Trans. 24. 3. pp. 168–183, 1922–1923.)—The optical designer is mainly concerned with the removal or reduction of a number of aberrations in an optical system which has to satisfy certain requirements as to dimensions, position of lenses, field of view, etc. Sometimes the production of specified aberrations, and not their removal, is aimed at. The author aims at providing a method for the direct calculation of a system which will automatically fulfil the conditions initially laid down for observance. This paper deals with the foundations of a theory designed to enable this to be done. By following the procedure outlined, only systems which fulfil the conditions are obtained. Whether the systems can actually be constructed depends on a number of additional considerations such as the existence of suitable kinds of glass. If the solution obtained is unsatisfactory in any of these respects, it is necessary to make a change in one or more of the initial assumptions and repeat the calculations on the modified basis. In this way, either a satisfactory solution will be obtained or alternatively the conclusion may be drawn that no acceptable solution exists. The use of the method evolved is illustrated by a lens of three elements such as the "Cooke" photographic lens. J. W. T. W.

2142. *System of Photometric Nomenclature Applicable to Optical Systems.* **P. G. Nutting.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 407–414, June, 1923.)—Starting with the four quantities (i) luminous flux, (ii) flux per unit area, (iii) flux per unit solid angle, and (iv) flux per unit solid angle per unit area (brightness), the author shows that the lighting characteristics of any optical system may be defined. The third quantity above mentioned, usually applied only to divergent pencils and then called luminous intensity, may be applied equally to convergent pencils and so with brightness, or luminous intensity density. Examples of the application of the system to such cases as image projection, the formation of the retinal image by the eye, etc., are given in the paper. J. W. T. W.

2143. *Resolving Power of Microscopes and Test Plates for Microscope Objectives.* **A. Mallock.** (Nature, 112. pp. 130–132, July 28, 1923.)—The author gives reasons for believing that the least distance which must separate two points in the focal plane, if they are to appear as separate points in the image is approximately $0 \cdot 7\ \lambda$. The amplitudes at points in the image plane close to the geometrical image of a point are calculated for different lens apertures. The author points out that the result of a test of resolving power is affected by the thickness of the markings on the test object employed. When the thickness is a small fraction of the wave-length of the light employed, the resolving power cannot exceed the limit above mentioned and probably this limit is an over-estimate. J. W. T. W.

2144. *Device for Rotating Spectrometer Crystals.* **P. Kirkpatrick.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 539–541, July, 1923.)—

A ratchet and sprocket wheel are mounted on a common horizontal shaft placed on a shelf directly on the axis of a Bragg spectrometer. The ratchet can be rotated in an intermittent manner by a pawl actuated by an electromagnet, the resulting rotation of the sprocket being transmitted by a chain to a lower sprocket integral with the head of the tangent screw which imparts slow motion to the spectrometer crystal holder. A second pawl held against the ratchet wheel by a spring prevents any tendency of the wheel to rotate in the wrong direction due to friction with the first pawl. A lever disengages the pawls when backing off the tangent screw preparatory to a setting. A rocker and mercury cups are attached to a metronome and perform the function of admitting accurately timed current impulses to the electromagnet. The switches, with the metronome slider, give a range from 20 to 208 advances of the crystal per minute. In addition the rotating device aids in locating spectral lines, absorption discontinuities, etc. T. C. H.

2145. *Image Formation by a Straight Edge.* **S. Ray.** (Phil. Mag. 46. pp. 79–80, July, 1923.)—If light is passed through a number of parallel slits, which therefore serve as independent sources, a straight edge held parallel to the lines will produce on a screen an inverted image of the slits. The phenomenon is explained by assuming that the first maximum of the diffraction fringes due to each source can be considered as entirely outweighing the remainder. Photographs of the effect are given.

J. W. T. W.

2146. *Production of Light by Stimulated Atoms.* **F. Schröter.** (Zeits. f. Physik, 15. 6. pp. 322–338, 1923.)—In this paper the author attempts to add something to our knowledge of the phenomena which take place in the process of luminescence caused by the inelastic impact of electrons against the atoms of a metallic vapour. The possibility of the method is considered as a means of practical illumination. The conclusions arrived at do not appear at present very hopeful from a technical point of view. T. B.

2147. *Diffraction Pattern in the Case of Two very Close Point Sources of Light.* **B. E. Mourashkinsky.** (Phil. Mag. 46. pp. 29–49, July, 1923. Paper read before the Russian Astron. Soc., April, 1922.)—Considers the exact meaning of the term " resolution " as applied to the images of two close point sources of light and suggests that it should be used to denote the least distance between the sources at which a distribution of illumination in the diffraction pattern due to both the sources is such that the difference between the maximum illumination (on the meridional line) and that at the central minimum is just perceptible to the eye. It is pointed out that this difference limen depends on the contrast sensitivity of the eye, and is therefore affected by the absolute brightness of the field.

There is a further consideration of very great importance when the diffraction patterns of two images overlap, as they do in the case of very close objects such as those treated by the author. It is clear that owing to the superposition of the two diffraction patterns, one due to each source, the maxima of intensity may be shifted slightly from the positions which correspond to the maxima of the two patterns when each is taken independently. This effect becomes increasingly important as the intensities of the sources become more unequal, and extensive tables are given in the paper to show (*a*) the distribution of intensities on the line joining the geometrical images, and (*b*) the displacements of the maxima and intermediate minimum, when the ratio of the intensities has various values from 0·9 to 0·01. In the plate attached to the paper are given isophot (isolux) diagrams for certain typical cases.

The author points out that probably in some cases the eye cannot detect the difference between the maximum and minimum illuminations on the meridional line, but that it can detect the "depression" in the middle of the illumination contour figure. **J. W. T. W.**

2148. *Radiation Measurements with Platinum and Tungsten.* **F. Henning** and **W. Heuse.** (Zeits. f. Physik, 16. 1. pp. 63–70, 1923. From the Reichsanstalt.)—A description is given of a micro-pyrometer which is employed to determine the emissive powers of platinum and tungsten at different temperatures. The microphotometer is also used in a re-determination of the melting-point of tungsten.

The emissive power of platinum and tungsten was found to be independent of temperature (for Pt between room temperature and 1710°, for tungsten between 2000° and 3200° C.).

Metal.	Emissive Power.*	
	λ = 0·647 (red).	λ = 0·536 (green).
Platinum	0·348	0·363
Tungsten	0·49	0·49

* Emissive power of a body is defined as the ratio of its radiation intensity to that of a black body at the same temperature and wave-length.

The melting-point of tungsten was found to be 3370° C. in good agreement with the value found by Pirani and Alterthum [Abstract 1416 (1923)], *viz.* 3387° C. ± 60° C. A. B. W.

2149. *Influence of the Earth's Rotation on Optical Phenomena.* **H. A. Lorentz.** (Nature, 112. pp. 103–104, July 21, 1923.)—The different ways in which the motion of a system (*e.g.* the earth's rotation) can be detected by optical phenomena are briefly described in succession. The Doppler effect due to the earth's translational motion is easily detectable, that due to its rotation is scarcely so. It gives no clue as to the state of motion of the medium surrounding the earth.

The modification in the propagation of waves and rays of light, due to a motion of the ether relative to the system, can be found by Huygens' construction. The presence of an ether whirl surrounding a rotating planet has not been detected in observations of occultation by Jupiter. Fresnel's theory of aberration explains the phenomenon on the assumption of no ether whirl. An experiment, due to Michelson, is described and an imaginary experiment for showing the relative motion of earth and ether is also mentioned. If two parallel, perfectly conducting wires were placed round the equator, each forming a closed circle, and if standing electromagnetic waves were set up between these wires, then relative motion of earth and ether would result in the loops and nodes travelling around the earth from east to west in twenty-four hours. J. W. T. W.

2150. *Simultaneous Measurements by Trichromatic and Monochromatic Analysis.* **H. E. Ives.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 287–298, April, 1923.)—Two different systems of colour-measurements are in use, the trichromatic, in which three primaries are mixed to form a match with the colour studied, and the monochromatic whereby colours are matched by mixtures of some standard colour of low saturation, with any one of a continuous series of colours of high saturation. Measurements by the two methods should be capable of correlation, but there are several difficulties. The "whites" used for reference may not be the same, measurement of the relative luminous values of the colours examined is uncertain, and the algebraic transformation processes necessary for intercomparisons are not available in a convenient form. The author describes a series of measurements made by the two methods using for "white" a 5000° black body and a convenient graphical form of the algebraic transformations. The results, recorded in tabular form, show distinct differences. Monochromatic analysis invariably indicates a longer wave-length, and also the purity is less. The causes of disagreement are discussed. The fundamental sensation curves must be slightly altered in the yellow and the purity steps must be more nearly equal in the white to yellow region. Greater attention must also be paid to the particular characteristics of the observer's eye. J. S. D.

2151. *Observation of Weak Absorption.* **E. Madelung** and **R. Götze.** (Phys. Zeits. 24. pp. 257–259, June 15, 1923.)—The principle of the method is as follows: When light is admitted to an interferometer, and the fringes are cast upon the slit of a spectroscope, fringes are also found in the spectrum, as alternations of dark and light portions of the spectrum. If the slit is narrow, and is occupied mainly by a dark fringe, then practically the whole spectrum will be dark, and *vice versa.* Now if an absorbing medium is placed in one of the interferometer paths, the intensity of interference will be decreased, and the absorption will appear as dark in the bright fringes, and bright in the dark fringes. Thus by the latter process absorption may be made evident as light on a dark background, instead of the more usual reversed state of affairs. This method requires the black fringes to be as dark as possible, and therefore the two interfering rays must be as nearly as possible of equal intensity. Also the interferometer must be simple to adjust and line-up. A special form of interferometer was specially designed, and is here described. A. C. M.

2152. *A Simple Method of Measuring Absorption in Ultra-Violet Light. Part II.* **C. Winther.** (Zeits. wiss. Phot. 22. pp. 125–130, June, 1923.)—This forms a continuation of the work previously described by the author in collaboration with Baggesgaard-Rasmussen and E. Schreiner [see Abstract 2401 (1922)]. In the present experiments the nets used were (1) a simple brass wire net with 25 meshes per cm., the wire thickness being 0·15 mm. The net was burnt black and fastened in a brass ring. (2) A double net made from two blackened single nets. The method of carrying out the experiments is described and a diagram given showing the relative positions of the lamp, the lens, the net, the absorption tube, and the slit of the spectrograph. The extinction coefficients are calculated according to the following formula $\epsilon = \frac{a}{c \cdot d}$, where a the extinction of the used nets, c the molar concentration of the solution, d the thickness of the layer. A table of results obtained with 0·002 molar solution of salicylic acid. The comparison between measurements with single and double nets show the net-method admits of very great accuracy.

A. E. G.

2153. *On the Fine Structure of Absorption Limits at High Frequency.* **A. Lepape** and **A. Dauvillier.** (Comptes Rendus, 177. pp. 34–37, July 2, 1923.)—Kossel's theory relating to the fine structure of absorption limits only acquires a precise experimental significance in the case of absorbents in the atomic state, rare gases or metallic vapours, and this structure should be more apparent as the frequency is more feeble. With the object of investigating this phenomena, the limits L of xenon have been examined. Experimental details are given together with a very full discussion of the results for which the paper should be consulted.

H. H. Ho.

2154. *An Adaptation of the Thalofide Cell to the Measurement of Photographic Densities.* **A. L. Schoen.** (Eastman Kodak Co.'s Research Lab., Comm. No. 171. Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 483–490, June, 1923.)—An application of the thalofide cell to the determination of very small differences of photographic densities is briefly described. The cell is illumined by light transmitted through the photographic strip under test, and its resistance maintained at a constant value by adjusting the distance between the source of illumination and the cell. With the cell employed in the present work, maximum sensitivity was obtained when 40 volts were applied to the cell terminals and the light-sensitive part of the cell illumined with an intensity equal to 0·3 foot-candle. The method is especially applicable to determining the photographic density of emulsions containing a single layer of silver grains, for which the transmission coefficient is of the order 99 %.

J. S. G. T.

2155. *The Absorption Produced by Electrically Luminescent Sodium Vapour.* **F. H. Newman.** (Phil. Mag. 46. pp. 22–28, July, 1923.)—A condensed electric discharge was sent through sodium vapour maintained at 300° C. and contained in a quartz tube about 50 cm. long with a narrow constriction at one end. The light from the constriction was viewed through a quartz window at the end of the wider portion of the tube. The D lines alone showed self-reversal, and passing white light along the length of the tube simply gave absorption of the same lines. The density of the free electrons within the tube is comparatively small. Other experiments with sodium-potassium vapour are described and various spectrograms are given.

J. J. S.

2156. *Dispersion of Light by an Electron Gas.* **L. Page.** (Astrophys. J. 57. pp. 238–242, May, 1923.)—The electromagnetic theory of the dispersion of light passing through an electron gas—as, for example, possible swarms of electrons or protons in interstellar space—is mathematically deduced. The phase velocity in such a gas is found to be a function of the wave-length slightly greater than the velocity of light in a vacuum. On the basis of Shapley's estimate of a maximum difference between the velocities of blue and yellow light, the upper limit to the number of electrons (3×10^{11}) or of protons (5×10^{14}) per c.c. of interplanetary space is computed—protons possessing a smaller dispersive effect on account of their greater mass. The expressions obtained for the electric and magnetic vectors are checked both by the law of conservation of momentum and that of energy. A. B. C. L.

2157. *On the Photographic Intensity of Flashlight Materials.* **E. Huse.** (Frank. Inst., J. 196. pp. 391–395, Sept., 1923.)

2158. *An Improved Method of Computing the Velocity Constant of Development and Gamma Infinity.* **F. F. Renwick.** (Phot. J. 63. pp. 331–333, July, 1923.)—The author points out the tedious calculations involved in the usual methods for computing the above constants, and puts forward a new graphical method which gives the desired constants without any calculations. The values γ/γ_∞ and k are plotted as ordinates and abscissæ, respectively, for various values of the time t, in the general development equation $\gamma = \gamma_\infty (1 - e^{-kt})$. An ordinate through this series at the correct value of k for a given emulsion must intersect each curve at the value of γ/γ_∞ which is proportional to the real gamma found experimentally for the time of development t_1, t_2, t_3, etc., for which the curve has been calculated. Examples of charts constructed in this manner are given. A. W. J.

2159. *The Quantum Theory of Normal Photo-Effects.* **W. Bothe.** (Zeits. f. Physik, 17. 2. pp. 137–151, 1923. From the Reichsanstalt.)—This is a theoretical paper and is mainly of a mathematical nature. After a brief discussion of the basis of the theory the subject is discussed under the following heads: The quantum free from turning impulse. The comparison of experimental results with results obtained by calculation from the formula here given. The quantum with turning impulse. The comparison of this with experimental results. Remarks upon the question of the structure of light-quanta. A. E. G.

2160. *Animal Luminescence.* **E. N. Harvey.** (Frank. Inst., J. 196. pp. 31–44, July, 1923.)—Distinction is drawn between animal luminescence due to parasitical bacteria, which is continuous and independent of stimulation, and luminescence which is a definite-function of particular organs, such luminescence in general requiring stimulation for its production. Special attention is given to the cases of *Cypridina*, a crustacean presenting extracellular luminescence and to a mollusc, *Pholas*, from which latter two enzyme-like substances, luciferin and luciferase can be extracted, the physical and chemical deportment of which are described. A. B. C. L.

2161. *Vacuum Grating Spectrograph.* **T. Lyman.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 495–499, June, 1923.)—Describes a spectrograph designed to accommodate a grating of 50 cm. radius and to enable the source of light to be brought sufficiently near the slit to illuminate the whole surface of the grating (5 × 3 cm.). The photographic plate is so mounted that it may be moved two or three millimetres towards or away from the grating. Its inclination can also be adjusted. The instrument is described in detail and illustrated diagrammatically in the paper. J. W. T. W.

2162. *Duration of the Process of Light Emission in Hydrogen.* **A. J. Dempster.** (Astrophys. J. 57. pp. 193–208, May, 1923.)—Previously described experiments [see Abstract 904 (1920)] on the dying out of a beam of moving luminous sources in hydrogen canal rays in 2–4 cm. are repeated, and modified in order to investigate the conditions under which the dying out is most prominent. The upper limit found for the time of duration of this radiation process is 10^{-7} seconds. No luminous rays are present that die out in a much shorter distance. With different discharge conditions a second type of moving luminous particles appears, showing no dying out, the radiation process lasting longer than 5×10^{-7} seconds. With low pressures these are much more intense than the short-lived particles. Both types of luminous particles are neutral, and their luminosity is not altered in intensity by a strong electric field. The results are discussed in relation to other light-emission phenomena and it is suggested that the first type of particles may be neutral hydrogen atoms, and that the second type of luminosity may be a secondary phenomenon following the dissociation of a neutral molecule. Stark effect observations in a variable electric field lead to the assumption that the duration of the elementary atomic radiation process requires less than 3×10^{-10} seconds, which short time may be reconciled with one interpretation of the present experiments, but is not in agreement with the duration of the atomic radiation associated with the classical interpretation of the homogeneity of spectrum lines. A. B. C. L.

2163. *On the Masses of the Particles which Emit the Secondary Spectrum of Hydrogen.* **Duffieux.** (Comptes Rendus, 176. pp. 1876–1879, June 25, 1923.)—Hydrogen can emit two spectra of very different structure in the visible region, one constituted by the Balmer series and the other very complex and termed for a long time the band spectrum of hydrogen, but now generally styled as the secondary spectrum. The Balmer series is attributed to atomic hydrogen and the band spectrum to molecules. Fabry and Buisson have attributed both spectra to the atom and deduced the mass of the luminous particles by means of the formula, $N = 1 \cdot 22 \times 10^6 \sqrt{m/T}$, where N is the limit of interference, T the abs. temp., and m the mass of the particles. More recently Merton has determined the width of the hydrogen lines by an entirely different method, and he concludes that the Balmer series is due to the atom and the secondary spectrum to the molecule. On the request of Fabry and Buisson the author has repeated their experiments to the limit of interference. The apparatus employed is that already utilised by the author for the study of the spectrum of CO and of N [see Abstract 2286 (1922)]. The hydrogen was carefully purified, and, in the regions examined, its spectrum was identical with that described by Merton. About 30 lines in the orange and yellow have been examined visually, while the blue group between the lines H_α and H_β has been studied by photograph.

The numerical coefficient in the above formula is now found to be somewhat arbitrary, depending on small variations of perceptible brightness in the fringes. A detailed discussion of the data is included, from which the author concludes without hesitation that the secondary spectrum must be attributed to the molecule of hydrogen. H. H. Ho.

2164. *Secondary Hydrogen Spectrum.* **M. Kimura** and **G. Nakamura.** (Japanese Journ. Phys. 1. 9–10. pp. 85–95, 1923. In English.)—The secondary hydrogen spectrum was studied under different modes of excitation:

(*a*) With a strong magnetic field.
(*b*) With a constriction in the path of the discharge.
(*c*) In the neighbourhood of a kathode.
(*d*) As an electrodeless discharge.

It was concluded that the part of the spectrum enhanced in a constriction was emitted by ionised molecules (spark type) while the part enhanced in the wider part of the tube were due to un-ionised molecules (arc type). The Fulcher s_1 bands therefore belong to the spark type, while s_3, s_5, s_6, s_7 belong to the arc type. A. C. M.

2165. *Colloidal Supports for Obtaining the Emission Spectra of Solutions.* **J. Errera.** (Comptes Rendus, 176. pp. 1874–1876, June 25, 1923.)—The study of the emission spectra of solutions is of great interest in qualitative chemical analysis and for investigating lines of great sensitiveness, such as the ultimate lines of Gramont. Experimental arrangements are now described for obtaining such emission spectra. In the first attempts the spark was passed between a metallic wire and the solution, and has the inconvenience of giving foreign rays due either to the electrodes or to impurities of the glass. Gramont in 1907 had proposed an arrangement whereby the spark passes between two drops of the liquid placed one above the other at the ends of two silica capillary tubes. The present method adopts this principle, but depends on the diffusion of ions throughout a colloidal support and not on capillarity. Details are given for preparing the pure jelly and of electrodes prepared from jelly solutions of the ions required. By successive dilution the ultimate lines have been determined for silver, cadmium, mercury, calcium, magnesium, and copper ions. A Féry spectrograph with quartz prism was employed.
H. H. Ho.

2166. *The Einstein Spectral Shift.* **F. Croze.** (Ann. de Physique, 19. pp. 93–229, March–April, 1923.)—A complete account of the work done on the shift towards the red to be expected in the lines of the solar spectrum, compared with the same lines on the earth. This shift, due to the difference in gravitational potential on the earth's surface and at the surface of the sun, should be proportional to the wave-length, but independent of the intensity and of the chemical nature of the source of the line. The shift is nil for the Fraunhofer cyanogen lines of feeble intensity from the centre and edge of the solar disc, but the shift is dependent on the intensity, and this is found to be true of other metallic lines. It is not proportional to the wave-length, and it varies from one element to another. It is concluded that the observed shift must probably be attributed to a combination of the Doppler-Fizeau effect, pressure-effect, and dispersion. **A. C. M.**

2167. *Fraunhofer Displacements and Einstein's Theory.* **F. Croze.** (J. de Physique et le Radium, 4. pp. 198–221, June, 1923.)—Einstein's theory demands a shift towards the red of amount $d\lambda = \lambda \,.\, 2{\cdot}1 \times 10^{-6}$, giving for $\lambda = 5000$ Å.U. an increment of 0·105 Å.U. Displacements are found, but not exclusively towards the red; these displacements can be explained by means of anomalous dispersion. If a beam of white light passes through a medium absorbing selectively, not only the actual rays will be absorbed, but a small region on either side. According to Rayleigh, $I = I_0 e^{-sl}$, where I is the intensity of a beam of original intensity. I_0 after traversing a thickness l of absorbing medium; $s = \frac{32\pi^3}{3}\left(\frac{n-1}{N}\right)^2 \frac{N}{\lambda^4}$, where N = number of absorbing particles in unit volume, and n = refractive index for the wave-length λ. Now $(n-1)^2$ is greater on the red side of an absorption band; consequently in general the Fraunhofer lines will seem displaced slightly towards the red, as in measuring the position of the line one sets the cross-wire at the centre of gravity of the line. It is clear also that the displacement should vary with the intensity of the line. **A. C. M.**

2168. *Oxyacetylene-Flame Spectra.* **A. de Gramont.** (Comptes Rendus, 176. pp. 1104–1109, April 23, 1923.)—The usual commercial arrangement is employed, using dissolved acetylene and compressed oxygen [see Abstract 464 (1914)]. The flame has a higher temperature and gives brighter spectra than the oxyhydrogen or oxy-coal-gas flames. The regions conveniently investigated are limited by the water-vapour bands produced by the flame itself, and so is inferior to the condensed spark. However, it is particularly convenient for the alkalies and alkaline earths, copper, silver, gallium, indium, thallium, chromium, manganese, iron, cobalt, nickel, tin, lead, and bismuth. For most elements the "raies ultimes" obtained are the same as those obtained using other sources. It can be usefully applied to the spectroscopy of minerals. **Erratum** (*ibid.* p. 1268, April 30, 1923). A. C. M.

2169. *Induction Spectra and Spark Spectra.* **L. Dunoyer.** (Comptes Rendus, 176. pp. 953–955, April 3, 1923.) **L. and E. Bloch.** (*Ibid.* pp. 1062–1063, April 16, 1923.) **Erratum.** (*Ibid.* p. 1268, April 30, 1923.) **L. Dunoyer.** (*Ibid.* pp. 1213–1214, April 30, 1923.)—(1) The author points out the previous use of the apparatus employed by L. and E. Bloch [see Abstract 314 (1923)] for the production of spark spectra of different order, using the electrodeless discharge, by Hagenbach, Frey and Schumacher, McLennan, Robertson and van der Lingen. He suggests the use of the term "Induction-Spectra" instead of "Spark Spectra of Higher Order," which the Blochs employ, claiming that it is more natural to describe them by the method used, analogously to arc spectra and spark spectra.

(2) **L. and E. Bloch** claim that Dunoyer has nowhere in his publications indicated that different orders may be detected amongst the spark spectra, and in that case could not apply his method to distinguish between them.

(3) **L. Dunoyer** replies in detail to the above. **A. C. M.**

2170. *Series Spectra and Potentials of Cr and Mo.* **A. Catalán.** (Comptes Rendus, 176. pp. 1063–1065, April 14, 1923.)—In the papers referred to in Abstracts 1142 and 1143 (1923), the author has published two parallel systems of triplets A and B in the spectrum of Cr, and a system A for Mo. He now gives the system B for Mo. The first member of the principal series in the system A of Mo are the "raies ultimes" of A. de Gramont. The ionisation potentials calculated from these spectra are 6·7 and 7·1 volts, and the first resonance potentials are 2·89 and 3·19 volts for chromium and molybdenum respectively. A. C. M.

2171. *Mercury and Krypton Spectra as Units of Measurement.* **A. Pérard.** (Comptes Rendus, 176. pp. 1060–1062, April 16, 1923.)—Discrepancies greater than the experimental error would warrant exist between measurements of the wave-lengths of the four most intense mercury lines; these are attributed to the presence of satellites. These lines are now investigated, together with some krypton lines, with a view to using them as standards instead of the well-known Cd lines. For mercury a Cooper-Hewitt lamp was used, and for krypton a spectrum tube with platinum electrodes, containing the gas at a pressure of 4 mm. Graphs are given showing the results of many determinations, comparing these wave-lengths with that of the red Cd line. The wave-lengths of the four mercury lines and of the two krypton lines are given to eight significant figures; the positions of the satellites are also calculated.

A. C. M.

2172. *Spectrographic Researches of High Frequency in the Group of the Rare Earths.* **A. Dauvillier.** (Comptes Rendus, 176. pp. 1381–1383, May 14, 1923.)—The author has previously given an account of his study of the L series of lutecium and ytterbium [see Abstract 2086 (1922)], and in the present paper gives the results of his examination of those of cerium, neodymium, samarium, europium, and gadolinium. A table of the wave-lengths of these rays is given. The absorption lines L_1 and L_2 discovered for barium have been followed to gadolinium. They cease to exist before ytterbium and below cæsium. The author thinks that they correspond to the *reversal* of the lines β'_5 and γ'_2 (P_3L_1 and P_3L_2) following P_3 ionisation (expulsion of the valency electrons) maintained by the kathode bundle in the case of very electropositive elements. The greater part of the lines already observed for barium are found in the case of the elements of the group of rare earths. The measurements show that the layer of electrons N is tetraquantic with ten normal levels before the appearance of the rare earths and becomes so without doubt for the preceding tetravalent element, tin. It is for that element that the rays β_5 and γ_2 should appear for the first time. The existence of the provisional levels N'_8 and N'_9 before the rare earths and N'_7 at their beginning constitutes a phenomenon which is still inexplicable.

J. J. S.

2173. *Series Spectra of the Aluminium Sub-Group.* **J. A. Carroll.** (Roy. Soc., Proc. 103. pp. 334–338, May 3, 1923.)—Evidence is given that the normal state of the atom in this sub-group is for the valence electron to be in the 1π orbit, and excursions take place to and from this orbit, while in the alkali metals, for example, the normal orbit is the 1σ orbit.

An indication is the reversal due to absorption in the non-luminous vapour: in the alkalies only the principal series ($1\sigma - m\pi_{1,2}$) are reversed, while aluminium, gallium, indium, and thallium show well-marked reversals in the arc, in the subordinate series, and very feeble, if any, reversals in the principal series. This is not conclusive, as in the arc the atoms might be in an excited condition.

The absorption of Tl vapour was investigated in this present work, using an iron tube wound round with nichrome wire, over the range λλ7000–2500. The Tl was heated in an atmosphere of nitrogen. Thus it was found that the lines of the sharp and diffuse series could be reversed with ease, while no trace of absorption of the principal series was found. The normal orbit for the Al sub-group is therefore the 1π orbit; this is borne out by Bohr's theory, since thallium, for example, will have the outermost electrons two in 6_1 orbits, and one in a 6_2 orbit; this latter is responsible for the arc spectrum. A. C. M.

2174. *Band Spectra and Electronic Configuration of N_2 and CO.* **H. Nagaoka.** (Japanese Journ. Phys. 1. 7–8. pp. 49–57, 1922. In English. Phys. Math. Soc. Japan, Proc. 5. pp. 35–43, April, 1923. In English.)—Comparison of the physical properties of the gases N_2 and CO suggest that their molecular structure must be similar. Consequently their band spectra would also be similar, with the differences introduced by the presence of symmetry in the N_2 molecule and of asymmetry in the CO molecule, since the O atom will be heavier than the C atom. The actual numbers for the heads of the bands in the two spectra agree very well; in many cases the head of the band in the CO spectrum agrees with the mean of a doublet in the N_2 spectrum, while in others it is single band-heads which agree. A. C. M.

2175. *Ammonia Spectrum.* **W. B. Rimmer.** (Roy. Soc., Proc. 103. pp. 696–705, July 2, 1923.)—There are three main bands attributed to ammonia; that in the u.v. was investigated by Fowler and Gregory [see Abstract 1048 (1919)]. The present work deals with the "Schuster bands," λ5635 and λ5670, and the "α-band," which extends through most of the visible region. The Schuster bands give no sign of resolution under high dispersion, and probably do not occur in the solar spectrum. The α-band contains over 3000 lines; there is not sufficient evidence that this band occurs in the solar spectrum or in sunspot spectra. The author concludes from various experimental data that the u.v. band is due to the most stable combination of N and H, while the Schuster bands are due to the weakest combination, with the α-band intermediate. Additional evidence is the certain occurrence only of the u.v. bands in the sun's layer. A. C. M.

2176. *Spectrum of Trebly-Ionised Silicon.* **A. Fowler.** (Roy. Soc., Proc. 103. pp. 413–429, June 1, 1923.)—This work comes as an extension to the formula for spark spectra, containing the factor "4N," discovered by the author and described in Abstract 1680 (1914). Spectra are now found for silicon with factor 9N and 16N, and are attributed in consequence to doubly- and trebly-ionised silicon. The sources were arc and spark discharges between silicon electrodes, and vacuum tubes containing fluoride or chloride of silicon. Quartz-spectrographs and a Schumann vacuum spectrograph (Hilger pattern). The trebly-ionised silicon spectrum, Si(IV), corresponds with the Na(I) spectrum. The main series are in the far ultra-violet, and the secondary series falling in the ordinary range correspond with Na series in the infra-red. The spectra are compared for Na(I), Mg(II), Al(III), and Si(IV), four similarly constituted atoms; the series constants show more regularity than do the elements of the same chemical family. Si(IV) has an ionisation potential of 44·95 volts. A. M. C.

2177. *The Vacuum-Spark Spectrum of Silicon.* **R. A. Sawyer** and **R. F. Paton.** (Astrophys. J. 57. pp. 279–293, June, 1923.)—Silicon electrodes less than a millimetre apart were mounted in a suitably designed brass box with a quartz window, the best obtainable vacuum was produced, and a highly condensed spark was obtained by the use of 70,000 volts. Lines of iron, aluminium, calcium, and oxygen and the strongest lines of hydrogen, nitrogen, copper, zinc, and titanium appeared as impurities. The wave-lengths of 227 lines attributed to silicon in the region λ6700–λ2100, together with the measurements of other observers, are given. An additional 75 lines are given as doubtful, since they were faint lines appearing on only one plate. In the intervals λ6700–λ5500 and λ4070–λ3400 the wave-lengths are believed to be accurate to within 0·2 Å. and in the intervals λ5500–λ4070 and λ3400–λ2100 to within 0·1 Å. [See also Abstract 1599 (1922).] AUTHORS.

2178. *Arc Spectra of Gadolinium and Dysprosium.* **C. C. Kiess.** (Bureau of Standards, Sci. Papers. No. 466. pp. 695–706, 1923.)—The arc spectra of gadolinium and dysprosium were measured from λ5500 to approximately λ9000, using spectrograms prepared by the author and also by Eder. The sources were gadolinium oxide and dysprosium oxalate. Most of the lines are faint, and several suggest band-heads. The lines given amount to 950 for Gd, and 800 lines for Dy. A. C. M.

2179. *Spectrum of Manganese.* **G. S. Monk.** (Astrophys. J. 57. pp. 222–233, May, 1923.)—This paper contains the results of interferometer measurements of the wave-lengths of a number of lines in the spectrum of Mn in the region λ4470 to λ6021, together with an examination of the stronger lines in that region for pole-effect, and their behaviour under moderate differences of pressure. A carbon arc with the lower, positive, pole bored out and filled with manganese dioxide was used as a source. The interference method used does not seem to be suitable for observations on *pressure-shift* in manganese, on account of the intrinsic wideness of many lines and their widening under pressure. There appears to be a correspondence between unsymmetrical broadening of the lines under pressure and *pole-effect.* Little or no pole-effect is observed with a carbon arc whose lower pole is filled with manganese chloride. A moderate effect is observed at the positive pole of a carbon arc filled with manganese dioxide, and a larger effect with an arc between metallic poles. The *wave-lengths* of about forty lines were measured with an accuracy estimated at 0·002 Å. These are given in tables. Lines of neon and lines of iron of group *a* were used as standards, the strongest component of Hg5461 being taken as an auxiliary standard. J. J. S.

2180. *Wide and Narrow Bands in Absorption Spectra.* **V. Henri.** (Comptes Rendus, 176. pp. 1142–1145, April 23, 1923.)—Absorption spectra of substances in solution are composed of narrow bands (from 10 to 30 Å.U.), arranged regularly in series, or of wide bands (200 to 500 Å.U.). Some have both types, and in this case the narrow bands are always in the least refrangible regions. On comparing the absorption spectra of a substance in solution and of the substance vaporised, one finds that narrow bands in the solution correspond to very fine bands in the vapour, while the wide bands correspond to wide bands, which cannot be resolved into finer constituent bands, whatever the dispersion. The production of the narrow bands is attributed to the series of stationary states of the molecule, the energy being determined by quantising the motions of the electrons, atoms, and molecule. The wide bands are not yet explained. The author gives a series of rules, founded on the observation of the types of band-spectra exhibited by different chemical substances. These rules give the type of spectra possessed by a substance possessing certain types of chemical bonds; *e.g.* substances having a single double bond C=C, C=O, C=N, the other atomic groups being all saturated, have only wide bands, whether in solution or in vapour. These "rules" lead to a theory that there is a polarity in the molecules, and that vibrations of groups of opposite polarity provide the possibility of stationary states.

A. C. M.

2181. *Ultra-Violet Absorption Spectrum of Narceine.* **P. Steiner.** (Comptes Rendus, 176. pp. 1379–1381, May 14, 1923.)—Narceine usually placed amongst the alkaloids of the isoquinoline group occupies in that group a place apart. The author has taken up again the study of the ultra-violet absorption of narceine using Henri's method. It has been found that the flattening of the curve drawn by Dobbie and Lauder corresponds to a wide absorption band of which the maximum has the wave-length $\lambda = 2707$ Å. about, and a coefficient of absorption ϵ of about 9800. The corresponding values of the minimum are $\lambda = 2539$ Å. and $\epsilon = 8000$. The absorption curve of narceine is given. Its general aspect resembles that of narcotine and of opianic acid. It is possible to detect spectrographically 0·05 mg. of narceine in 2(cm.)^3 of solvent.

J. J. S.

2182. *Ultra-Violet Absorption Spectrum of Paraquinone.* **F. W. Klingstedt.** (Comptes Rendus, 176. pp. 1550–1552, May 28, 1923.)—The absorption spectrum of hexane solution of paraquinone has been studied by the quantitative method of V. Henri. The normal absorption spectrum comprises in the visible portion from the green to the violet 14 narrow bands. The positions of these are given in a table. They may be distributed in three series of bands nearly equidistant and are very similar to those obtained for glyoxal and diacetyl [see following Abstracts 2184 and 2185] In the middle ultra-violet, for $\lambda = 2790$ paraquinone exhibits a wide band with molecular coefficient of absorption $\epsilon = 350$. In the extreme ultra-violet for $\lambda = 2410$ paraquinone possesses a very strong band with $\epsilon = 20{,}000$.

J. J. S.

2183. *Absorption Spectra of the Vapours of Various Quinones.* **J. E. Purvis.** (Chem. Soc., J. 123. pp. 1841–1849, Aug., 1923.)—The author has investigated the absorption of the vapour of *p*-benzoquinone and has compared this with the vapours of toluquinone, *p*-xyloquinone, thymoquinone, dichlorothymoquinone, and dibromothymoquinone. The vapours of α-naphthaquinone and anthraquinone were also examined. The results show that: (1) Each of the three solution bands of p-benzoquinone splits up into a series of narrower vapour bands and these occur on the less refrangible side of a wider absorption. (2) In o-toluquinone these vapour bands are fewer in number, but each solution band shows a few such bands when the substance is vaporised. (3) In xyloquinone and in thymoquinone there are a few narrow vapour bands corresponding to the least refrangible of the three solution bands, but there are no such narrow bands in the two more refrangible bands. (4) In the dichloro- and dibromo-thymoquinones the two bands are not resolved into narrower vapour bands and there are no vapour bands on the more refrangible sides of the visible spectrum. (5) In α-naphthaquinone and in anthraquinone there is no resolution of the solution bands into narrower vapour bands. (6) The increasing complexity of the p-benzoquinone compounds means the gradual disappearance of the narrower vapour bands and of the least refrangible of the three solution bands and at the same time the most refrangible band becomes stronger. These results confirm previous observations made by the author on benzene and many of its compounds. In general as the molecule increases in complexity the vapour bands become more like the solution bands. They indicate that each band has its origin in a separate and distinct type of oscillation. The introduction of various elements produces striking changes which show that the oscillating centres are influenced by such introductions.

J. J. S.

2184. *Ultra-Violet Absorption Spectrum of Glyoxal.* **A. Luthy.** (Comptes Rendus, 176. pp. 1547–1548, May 28, 1923.)—The absorption spectrum of glyoxal dissolved in hexane was studied with a high-frequency spark between electrodes of Al in water as source of light. The most notable fact observed was the occurrence of narrow bands. The spectrum may be divided into three regions. In the first between $\lambda = 4613$ and 3119 Å. 17 narrow bands were observed whose positions are given in a table. These narrow bands may be distributed in four series of equidistant bands, the mean interval between the successive terms being equal to $\Delta 1/\lambda$ 1480 cm.$^{-1}$. In the middle ultra-violet about $\lambda = 2800$ glyoxal shows a very wide band, the value of the molecular coefficient of absorption ϵ is about equal to 2·5; acetic aldehyde presents in the same region a wide band for which $\epsilon = 6{\cdot}2$. In the extreme ultra-violet there is also a wide band with maximum about $\lambda = 1950$ and $\epsilon = 35$. The absorption curve of glyoxal resembles that of diacetyl. [See following abstract]. The first region with the narrow bands is like that of paraquinone [preceding Abstract 2182].

J. J. S.

2185. *Ultra-Violet Absorption Spectrum of Diacetyl.* **G. C. Lardy.** (Comptes Rendus, 176. pp. 1548–1550, May 28, 1923.)—Using a solution of diacetyl in hexane and a source of light giving a continuous spectrum according to Henri's method the existence of a series of narrow bands in the violet region of the absorption spectrum of diacetyl has been proved. Four narrow bands have been observed with wave-lengths $\lambda = 4512$, 4380, 4241, 4054 Å., respectively, and molecular coefficients of absorption $\epsilon = 20{\cdot}5$, 18·75, 19·5, and 15. In the middle ultra-violet for $\lambda = 2800$ a wide band is observed resembling that given by acetone in the same region. The maximum for this band corresponds to $\epsilon = 13{\cdot}6$, for acetone $\epsilon = 15 \cdot 8$. In the extreme ultra-violet the absorption curve rises continuously. Comparing the absorption of diacetyl with that of glyoxal [see preceding abstract] it is to be noted that the substitution of the CH_3 groups in the place of the hydrogens produces a widening of the narrow bands of the first region, and a general increase of the molecular coefficient of absorption, which is three or four times greater for diacetyl than for glyoxal. The situation of the absorption bands is the same for the two compounds. J. J. S.

2186. *The Ultra-Violet Absorption Spectra of Eugenol and Iso-Eugenol.* **G. Thompson.** (Chem. Soc., J. 123. pp. 1594–1597, June, 1923.)—In a paper by Crymble, Stewart, Wright, and Glendinning (Chem. Soc. J. 99. pp. 451, 1911), it is stated that "of two isomeric substances containing two or more double bands, the compound, the molecule of which contains the longest chain of conjugations, will have the greater absorptive power in the region of the spectrum above that in which any absorption bands make their appearance." The method used by these workers was, however, not such as to enable a quantitative statement of the absorbing powers to be made. The present work was undertaken, therefore, with the view of obtaining figures for this property of eugenol and iso-eugenol. The apparatus consisted of a Hilger quartz spectrograph, size E_2, a Lewis photometer, and a condensed spark between nickel-steel electrodes. The method of taking the spectrograms was that described by S. J. Lewis (Proc. Roy. Soc., 1916, [B], 89, 327). The absorptive powers in terms of extinction coefficients were found in the region 4000 to 2300, and the ratio of these powers has been calculated over the region 3100 to 3650. It is shown that the rule connecting absorptive power and number of conjugations may be reversed in certain portions of the spectrum, although these portions may be far removed from those in which selective absorption occurs. The selective absorption of these compounds has also been studied and the effect of the number of conjugations has been found to be particularly great in this region. H. H. Ho.

2187. *The Zeeman Effect of the Arc and Spark Spectrum of Manganese.* **E. Back.** (Zeits. f. Physik, 15. 4–5. pp. 206–243, 1923.)—The object of the work described in this paper is to set as fully as possible by the side of the term system arranged by M. A. Catalán, the coordinate system of the magnetic term divisions. In this first part the principal members of the most important groups of lines only are dealt with. The results are given in an elaborate series of tables, and the various groups as well as the characteristics of individual lines are fully described. J. J. S.

2188. *Absorption Spectra of Arsenic Sulphide Sols.* **A. Boutaric and M. Vuillaume.** (Comptes Rendus, 177. pp. 259–261, July 23, 1923.)—If I_0 is the initial intensity of a beam of light of wave-length λ, and I the intensity after traversing the absorbing medium, then when the medium consists of a suspension of particles small compared with λ, log I_0/I varies inversely as λ^4. For larger particles, log I_0/I varies inversely as λ^n, where n is less than 4, and smaller as the particles are larger. A solution of $6 \cdot 2$ g. per litre did not obey these laws. If the results are represented by $I/I_0 = \epsilon^{-k/\lambda^n}$, the value of n increases as λ increases, being $3 \cdot 3$ for $\lambda 6400$, and 12 for $\lambda 5300$. The theoretical curve lies above the actual curve, except at $\lambda 6200$, where the value of n is 4. The curves are explained by supposing : (*a*) An absorption due to diffusion and which would, by itself, give the theoretical curve. (*b*) A selective absorption due to reflection of the rays from the surface of the granules ; consequently this should vary in the same sense as the total surface of the granules. The latter effect is found to be decreased when the size of the granules is augmented. A. C. M.

2189. *The Quantum Theory of the Complex Zeeman Effect.* **A. M. Mosharrafa.** (Phil. Mag. 46. pp. 177–192, July, 1923.)—A mathematical discussion whose aim is to show that a theory of the complex Zeeman effect is possible which assumes the essential features of Sommerfeld's theory of the atomic structure of the elements. J. J. S.

2190. *The K-Absorption Discontinuity of Krypton and Xenon.* **M. de Broglie** and **A. Lepape.** (Comptes Rendus, 176. pp. 1611–1612, June 4, 1923.)—The wave-length of the K-absorption line has been determined for argon, but not for krypton and xenon. The authors have found for the first, $\lambda = 0 \cdot 8648$ Å., and for the second $\lambda = 0 \cdot 3588$ Å. ; the last figure in each case is not claimed as being accurate ; the results are in accordance with Moseley's law. H. N. A.

2191. *High-Frequency K-Series Absorption Spectrum of Erbium.* **L. H. Martin.** (Roy. Soc. Victoria, Proc. 35. 2. pp. 164–168 ; Disc., 168–169, 1923.)—A critical absorption " edge " in the X-ray spectrum of an element has a wave-length such that the element absorbs X-rays of shorter wave-length than that of the edge more than X-rays of longer wave-length. This paper gives an account of the determination of the K " term " of erbium ($N = 68$). The value given for the erbium K absorption edge is $\lambda \mathrm{Er}_K = 215 \cdot 9 \times 10^{-11}$ cm. J. J. S.

2192. *L-Series of Hafnium.* **A. Žáček.** (Zeits. f. Physik, 15. 1. pp. 31–32, 1923.)—The relative values of the L-series are now determined, and the absolute values of the strongest lines, using a precision spectrograph of the Siegbahn type. The current in the X-ray tube was 20 ma. ; the total exposure was one hour (30 minutes each side). The wave-lengths are given for α_1, α_2, β_1, β_2, β_3. A. C. M.

2193. *New Lines in the L-Series of the Heavy Elements.* **P. Auger** and **A. Dauvillier.** (Comptes Rendus, 176. pp. 1297–1298, May 7, 1923.)—The author's observations confirm that the line L_2, one of Sommerfeld's doublets, does not exist, whilst on the contrary the L_1 lines can exist alone. Of the L-series of tantalum 25 lines have been identified, only 15 lines being previously known. The *k*-series of ruthenium have also been measured, thus completing the spectroscopy of the Zn-Cd series. A. B. W.

2194. *Quantum Theory of the Scattering of X-Rays by Light Elements.* **A. H. Compton.** (Phys. Rev. 21. pp. 483–502, May, 1923.)—The hypothesis is suggested that when an X-ray quantum is scattered it spends all of its energy and momentum upon some particular electron. This electron in turn scatters the ray in some definite direction. The change in momentum of the X-ray quantum due to the change in its direction of propagation results in a recoil of the scattering electron. The corresponding increase in the wave-length of the scattered beam is $\lambda_\theta - \lambda_0 = (2h/mc) \sin^2 \frac{1}{2}\theta = 0\cdot0484 \sin^2 \frac{1}{2}\theta$, where h is the Planck constant, m is the mass of the scattering electron, c is the velocity of light, and θ is the angle between the incident and the scattered ray. Hence, the increase is independent of wave-length.

The distribution of the scattered radiation is found to be concentrated in the forward direction according to a definite law. Results are given which show that for graphite and the M_0–K-radiation the scattered radiation is longer than the primary, the observed difference ($\lambda_{\pi/2} - \lambda_0 = 0\cdot022$) being close to the computed value 0·024. The predicted variation of absorption with λ is in excellent agreement with Hewlett's experimental results for carbon for wave-lengths below 0·5 Å. The predicted concentration in the forward direction is also in agreement with the experimental results both for X-rays and γ-rays. The remarkable agreement between experiment and theory indicates that the scattering is a quantum phenomenon and can be explained without introducing any new hypothesis or any new constants. A. B. W.

2195. *The Characteristic X-Radiation of the First Elements in the Periodic Table.* **J. Holtsmark.** (Phys. Zeits. 24. pp. 225–230, June 1, 1923.)—The author has previously measured the wave-length of the K radiation of boron and carbon [Abstract 2290 (1922)] by studying the photoelectric action of X-rays from an antikathode consisting of the element investigated, as depending on the kinetic energy of the electrons striking it. The commencement of K radiation is shown by a sudden rise in the photoelectric action at a definite accelerating voltage, and the frequency of the radiation is obtained from the equation $eV = h\nu$. The same method has now been used for lithium and beryllium; lithium oxide Li_2O having been used for the first and beryllium fluoride BeF_2 for the second element. There is some difficulty in the choice of a suitable compound for the purpose, as it must not evaporate easily, must contain a sufficient percentage of the element investigated, must conduct electricity, and the excitation points of the other elements contained in it must not be too near to that of the element investigated. In the last point Li_2O is not quite suitable; but the excitation point of oxygen differs just enough from that of lithium to enable it to be used; there are twice as many lithium atoms as oxygen atoms, and control experiments with an oxydised nickel anode showed no O radiation at 50 volts, so apparently it is much weaker than the Li radiation. One set of 8 curves gives for lithium 52·6 volts, and another of 3 curves 53·1 volts. The author considers the first number the more reliable. Beryllium was not so thoroughly investigated as lithium; the value obtained was 95 volts. The paper contains a table giving the excitation voltages for the elements from H to Na, obtained by different observers, and a diagram showing the relation between the atomic numbers N and the square root of the exciting voltages. Values obtained with gases are generally lower than with solids, and cannot apparently be directly compared with them. The elements from $N = 2$ to 5 behave differently from those following; but it looks as if Hughes' low value 215 for carbon belongs to a line of the same kind as the lines of the lower elements; the other value, about 289, obtained by different observers for carbon apparently corresponds to another K line. It is suggested that these lower elements, in the compounds investigated, contain only electrons which move in one quantum orbit, and so behave differently from elements which have two quantum orbits. H. N. A.

2196. *Very Soft X-Rays. The M-Series for Iron.* **G. K. Rollefson.** (Science, 57. pp. 562–563, May 11, 1923.)—By measuring the photoelectric current as a function of applied voltage the author has observed up to the present nine distinct breaks for iron in the region 40 to 185 volts. The values for these points are:

Voltage.	ν/R.	λ.
46·8	3·46	264 Å.
81·7	6·03	151
95·4	7·05	129·6
111·2	8·21	111·0
130·4	9·63	94·6
140·9	10·40	87·8
151·1	10·88	83·9
153·7	11·33	80·5
160·1	11·83	77·0

The wave-length λ is in Ångström units, ν is the frequency, and R the Rydberg constant. A. B. W.

2197. *The Deviation of X-Rays at the Surface of Bodies and the Effects Produced by a Slit.* **F. Wolfers.** (Comptes Rendus, 177. pp. 32–34, July 2, 1923.)—New experiments now described have enabled the author to confirm and extend the results of his previous communication [Abstract 1879 (1923)]. X-rays which just touch the surface of a body, such as tangents at the boundary of a screen, are deviated and give the appearance of a reflection. This phenomenon is general, but to observe it with substances which are very light, such as carbon, the rays must be very soft. With heavy bodies and soft rays, the reflection appears almost complete, and the maximum deviation with respect to the incident rays is proportional to the angle which the normal source makes with the contour of the object. The work is now extended to the action of slits upon X-rays, *i.e.* the superposition of effects from two neighbouring screens, and the results are of importance for spectrographic study of X-rays. Experimental details are briefly described. By irradiating a plate with a sufficiently large source from which the rays pass through a fine slit, the effects produced are found to depend on the width of the slit and on its distance from the plate. It matters little whether the slit has thin edges or thick or be formed by two parallel cylinders. If a conical slit be used then towards the apex the black bands near each edge begin to encroach with a maximum darkening at the centre. The image narrows little by little to become equal to the width of each of the black bands, then it does no more than wane while preserving a constant width. The appearance becomes more complex as the plate is removed from the slit, each of the two narrow black bands subdivides into two, and then into several fine lines, the ensemble presenting the appearance of interference fringes or a kind of spectrum. The interpretation of these new phenomena presents difficulty and necessitates new researches. The work of Fomm and Haga in this connection is mentioned, and also a recent application by Compton of the Drude-Lorentz theory of optical dispersion to X-rays. H. H. Ho.

2198. *Total Reflection of X-Rays.* **A. H. Compton.** (Phil. Mag. 45. pp. 1121–1131, June, 1923.)—The fact that Bragg's law of X-ray reflection from crystals ($n\lambda = 2D \sin \theta$) cannot be strictly true appears to have been pointed out first by Darwin [see Abstract 1079 (1914)], who gives for the difference between the observed glancing angle θ and the angle θ_0 anticipated by the Bragg formula

$$\theta - \theta_0 = \frac{1-\mu}{\sin\theta\cos\theta}$$

where μ is the index of refraction of the X-rays in the crystal. Since the refraction index is less than unity, a beam of X-rays striking a plane surface at a sufficiently large angle of incidence should be totally reflected. The critical glancing angle is given by $\cos\theta = \mu$,

or $$\sin\theta = \sqrt{2\delta} \text{ where } \delta = \frac{ne^2}{2\pi m\nu^2}$$

where n = total number of electrons per unit volume of the medium.

The question has been examined experimentally, and the critical angles of reflection of X-Rays from glass, lacquer, and silver measured. It is shown that in every case the reflection is truly specular.

Substance.	Density.	Wave-length, A.U.	Critical Angle θ Experiment.	$(1-\mu)$ Experiment.	$(1-\mu)$ Theory.
Glass	2·52	1·279	10′	$4{\cdot}2\times10^{-6}$	$5{\cdot}2\times10^{-6}$
Glass	2·52	0·52	4′	$0{\cdot}9\times10^{-6}$	$0{\cdot}7\times10^{-6}$
Silver	10·5	1·279	22·5′	$21{\cdot}5\times10^{-6}$	$19{\cdot}8\times10^{-6}$
Lacquer	—	1·279	11·0′	$5{\cdot}1\times10^{-6}$	—

The theoretical bearing of these results is discussed in conclusion, *e.g.* knowing the wave-length, it is possible to calculate from the observed index of refraction the number of electrons per atom which are affected by the incident X-rays. A. B. W.

2199. *X-Ray Diffraction Effects from Liquids and Liquid Mixtures.* **R. W. G. Wyckoff.** (Am. J. Sci. 5. pp. 455–464, June, 1923.)—"Liquid or glassy" X-ray diffraction patterns are produced from various pure liquids and their mixtures, and the resulting photographs analysed photometrically. These measurements are in agreement with the assumption that the pattern of a liquid mixture is the sum of the diffractions of its component liquids. The various hypothesis concerning the source of the bands in these patterns are mentioned, and it is pointed out that the present experiments favour an origin *within* rather than *between* molecules, but do not exclude the possibility of their arising from characteristic associations of molecules. The directions in which these preliminary observations should be made more precise are indicated. A. B. W.

2200. *Regularities in the Screening Constants of Röntgen Spectra.* **A. Sommerfeld.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 503–508, July, 1923.)—Two classes of doublets are distinguished in X-ray spectra, relativity doublets and screening doublets; the first can be accounted for, with a remarkable degree of accuracy, by the fine structure theory of hydrogen, and the difference in the energy ΔE divided by Rh is equal to

$$\frac{\Delta\nu}{R} = \frac{a^2(Z-s)^4}{n^4}\left(a_1 + a_2\frac{a^2(Z-s)^2}{n^2} + a_3\frac{a^4(Z-s)^4}{n^4} + \ldots\right)$$

where n is Bohr's total quantum number, 2 for the L doublet, 3 for the M doublets, 4 for the N doublets; a_1, a_2, and a_3 are rational numbers, composed of n and the azimuthal quantum numbers of the two energy levels concerned; for the L doublet they are 1, 5/2, and 53/8. For the L_1–L_2 doublet the screening constant s is 3·50, for the M_1–M_2 doublet it is $13\cdot16 = 3 \times 4\cdot39$, for M_3–M_4 $8\cdot25 = 2 \times 4\cdot12$, for N_1–N_2 $33\cdot9 = 8 \times 4\cdot2$, for N_3–N_4 $25\cdot7 = 6 \times 4\cdot3$, and for N_5–N_6 $16\cdot3 = 4 \times 4\cdot1$. The s values for the N doublets are not as exact as for the L and M doublets. The values of s for the M and N doublets are integral multiples of a common basic unit, which lies between 4·1 and 4·4, the integral multipliers being 2, 3, 4, 6 and 8; their growth corresponds to a passage from low to high energy levels; the nearer the levels are to the nucleus the less they are screened, and the smaller is the screening constant. The screening constant of the L doublet $s = 3\cdot50$ is certainly less than the basic unit of the remaining relativity doublets, and it is possible that the differences in the basic units of the M doublets may be real. Formulæ are also given for ν' and ν'' in the so-called screening doublets; these contain the screening constants σ' and σ'', which are known if the energy level in question occurs in a relativity doublet, as well as in the screening doublet under discussion. It is found that the various screening-constant differences are integral multiples of the same basic unit, 0·57, the multipliers being for L_3–L_2 2; M_5–M_4 3; M_3–M_2 6; N_7–N_6 4; N_5–N_4 8; N_3–N_2 12; in a general way this series shows the increased screening by successive shells. The final goal of X-ray spectroscopy, the determination of the K, L, M, N "terms," seems to be much closer than the corresponding one in the visible region. Attention is called to recent work on the screening effect by Bohr and Coster. H. N. A.

2201. *Relative Intensity of X-Ray Lines.* **F. C. Hoyt.** (Phil. Mag. 46. pp. 135–145, July, 1923.)—Bohr's correspondence principle states the general method of obtaining an estimate of the relative frequency of occurrence of different quantum transitions, but does not lead to an unambiguous expression for the intensity of a given line. Among various plausible expressions, however, it may be possible to discriminate by a comparison with experimental values. The present paper contains a brief discussion of the factors that must be taken into account in a complete theory of the intensity of X-ray lines, and some calculations are made on the basis of the simplest atomic model possible. A. B. W.

2202. *Reflection by a Crystal of X-Rays Characteristic of Chemical Elements in it. Abnormal Reflection.* **G. L. Clark** and **W. Duane.** (Nat. Acad. Sci., Proc. 9. pp. 126–130, and 131–135, April, 1923. Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 455–482, June, 1923.)—Since the announcement in a former note [Abstract 2052 (1922)] of a new method of crystal analysis by X-rays, the authors have made further experiments which have made it possible to detect and study separately the reflections of rays belonging to the characteristic line spectra of the different chemical elements in the reflecting crystal. In the crystals thus far investigated—KI, KI_3, CsI, CsI_3, and $CsIBr_2$—X-rays characteristic of cæsium, iodine, and bromine have been identified.

The method described consists in determining the spectrum of the reflection from a set of planes by using the "peak" (X-rays voltage) corresponding to that set, for example, the 100 planes, and then changing by steps the angles of both the crystal and the ionisation chamber, moving the latter at twice the rate of the former. Instead of finding a series of peaks corresponding to *different* sets of planes (as in the usual Bragg method) the reflection from the 100 planes *alone* is analysed.

Evidence has now been obtained to show that the abnormal reflection observed with a crystal of potassium iodide is due to the characteristic radiation of iodine. This has been proved by determining the critical value of the voltage below which the abnormal reflections do not occur. Substituting the experimental value 31·5 K-volts in the relation $Ve = h\nu = \frac{hc}{\lambda}$, a value for $\lambda = 0{\cdot}392$ is obtained, which is a wave-length lying between the α- and the β-lines in the K-series of iodine (*viz.* $\lambda_\alpha = 0{\cdot}437$, $\lambda_\beta = 0{\cdot}388$). A. B. W.

2203. *The Measurement of X-Ray Intensity and the Necessity of an International Unit.* **S. Russ.** (Phys. Soc., Proc. 35. pp. 5D–8D, June, 1923.)—The difficulties of ionisation methods of measuring X-ray intensity, when the wave-length varies, is mentioned and an equation $\frac{I_1}{I_0} = \frac{1 - e^{\mu_0 t}}{1 - e^{\mu_1 t}}$ is derived, in which the scattering coefficients are neglected in comparison with the absorption coefficients μ_0 and μ_1. To compare intensities these coefficients must be known, and recent work shows $\mu \propto \lambda^3$. A graph is given showing the relation of I_1/I_0 and wave-length. The above relation only holds under certain experimental conditions, and it is essential that secondary radiation should not vitiate the results. Experiments are described in which secondary radiation caused a 2½-fold variation of measured intensity of a common beam of rays. The author concludes by stressing the importance of an international unit of X-ray energy, but does not suggest any particular unit. B. J. L.

2204. *The Quality of X-Rays Produced by Various High-Tension Generators and an Incandescent Kathode Tube.* **F. J. Harlow** and **E. J. Evans.** (Phys. Soc., Proc. 35. pp. 9D–23D; Disc., 23D–25D, June, 1923.)—After passage through one centimetre of aluminium the coefficient of absorption of aluminium is approximately constant and the transmitted radiation, termed by the authors "end-radiation," varies for the same spark-gap with the method of excitation and in the induction-coil method with the length of interrupter contact. An experimental method of measuring the "end-radiation" to compare the relation of peak voltage and coefficient of absorption is described in detail, and this was utilised with various types of exciters, as induction coil, transformers, and Wimshurst machine. Absorption curves for different exciters, under conditions of same quality of "end-radiation," are indistinguishable, and hence the intensity distribution of the spectrum is the same. A like result was obtained by Dauvillier by a spectroscopic method. A practical unit of X-ray quality based on measurement of "end-radiation" after passage through 1 cm. of aluminium is suggested. A discrepancy between the authors' Wimshurst machine results and a constant potential arrangement of Dauvillier is explained by the authors as being due to Dauvillier's method actually giving an intermittent output. Experiment shows an intermittent radiation with the Wimshurst machine. In the *discussion*, **Kaye** criticises the term "end-radiation" and the authors' results.

B. J. L.

2205. *Practical X-Ray Measurements for Medical Purposes.* **M. Berry.** (Phys. Soc., Proc. 35. pp. 26D–32D; Disc., 32D, June, 1923.) —The medical radiologist should have a competent knowledge of X-ray physics, but differences arise since whereas the physicist is dealing with inanimate objects incapable of injury, the medical radiologist deals with living tissue capable of injury.

To increase depth dosage the cross-fire method is obvious, if it is practicable. Medical measurements resolve themselves into those of quantity and quality of radiation. Experiments, with boiling gas tubes and coil with mercury interrupter, are described to show the dependence of penetration upon rate of interruption, together with a description of an oscilloscopic method to determine the most advantageous interruption rate. Necessity of adjusting the "make" period of the interrupter is discussed. Variation of self-inductance and capacity of the coil is dealt with, and results of Seitz and Wintz show for any particular apparatus a marked optimum capacity. Results of the author, regarding variation of capacity, are given in tabular form. Practical methods of increasing depth dosage, without increased skin dose, by covering the body surface by material of similar absorptive power, are described and the most suitable materials (as paraffin wax or cellulose pulp). It is suggested ordinary dough would allow adaptation to the contours of the body without the necessity of a container. Back-scattered radiation is of importance in treating uterine cancer, where the gas-filled rectum is in close relation. Experiments in this connection are also given in detail.

B. J. L.

2206. *X-Ray Protective Materials.* **G. W. C. Kaye** and **E. A. Owen.** (Phys. Soc., Proc. 35. pp. 33D–39D; Disc., 39D–40D, June, 1923.)—The protective values expressed in terms of equivalent thickness of lead have been measured for a variety of materials. Numerically, 1 mm. of the material in question is equivalent to the following thicknesses of sheet lead in millimetres:

Lead glass (0·12 to 0·20), lead rubber (0·25 to 0·45), bricks and concrete (about 0·01), woods (0·001 or less), Bangtu plaster (0·05 to 0·13), steel (0·15). These figures relate to tungsten X-rays generated by 100,000 volts.

In the *discussion* reference is made to the importance of the work of the X-Ray and Radium Protection Committee, and the need for an International Committee on Standards of Measurement in Radiology.
A. B. W.

RADIO-ACTIVITY.

2207. *Relation between the Radio-Activity of Radium and the Activity of Solar Radiations.* **A. Nodon.** (Comptes Rendus, 176. pp. 1705–1707, June 11, 1923.)—Continues the research described in Abstract 119 (1923), using an electrometer instead of the photographic method. The absorbing action of different substances on the radiations emitted by radium under solar action increases in the order: celluloid, aluminium, mica, cardboard, lead; a sheet of black celluloid absorbs these radiations slightly, and the absorption in each case is of the same order as that of the same substances for the ultra-radiation from the sun, and from the higher atmosphere. The intensity of the ultra-radiation is much stronger in sunshine than in the shade and is feeble in a shut room and in a cellar; it increases during periods of solar activity, corresponding to a high value of the horizontal component of the magnetic field, and also with the elevation of the sun; it sometimes varies largely and rapidly without apparent cause. The absorbing power of different substances for these radiations seems to be of the same order as for γ-rays, being greater for substances with high atomic number. When thin sheets are used the slower radiations appear to be absorbed, and the faster get through; with large thicknesses only radiations with very short wave-length can pass. **H. N. A.**

2208. *Measurement of Radium Emanation by Means of α-Rays; Corrections due to Pressure and the Nature of the Gaseous Mixture.* **A. Lepape.** (Comptes Rendus, 176. pp. 1613–1616, June 4, 1923.)—Gives a table of corrections to be applied to measurements made with the apparatus of Cheneveau and Laborde. The condenser has the volume 3140 cm.^{3}; int. diam. 12 cm.; height (int.) 27·5 cm.; diam. of electrode 0·8 cm. The pressure was varied from 450 mm. to 800 mm., and the quantity of emanation from 2·5 to 28 millimicro-curies. The theory of the curves is discussed, and attention is called to the fact that variations of pressure have no effect above 720 mm.; ordinary variations of temperature are negligible; the corrections are greater with a small condenser. The effect of mixing different proportions of CO_2 with dry air has also been measured; this gas diminishes the ionisation current. The ionisation produced by α-rays is 23 per cent. more in CO_2 than in air; but the recombination of the ions along the trajectories of the α-rays is much more intense; when the potential of the central electrode is about 300 volts the resultant effect is an increase of the lack of saturation of the ionisation current. These corrections should always be made to measurements of radium emanation. **H. N. A.**

2209. *Photography of Disintegrating Atoms, etc.* **W. D. Harkins** and **R. W. Ryan.** (Nature, 112. pp. 54–55, July 14, 1923.)—The authors refer to a photographic expansion apparatus (of the Wilson type and similar to that of Shimizu) with which they have photographed as many as 80,000 α-particle tracks. Of these tracks, one, now reproduced, is particularly remarkable in that it shows a fork of 4 branches, *viz.* the main α-particle track, the deflected track (through an angle of 165°), the forward track of the nucleus hit by the α-particle, and an additional track due to the fragment (*e.g.* a hydrogen nucleus) ejected from the nucleus. From the assumed dimensions of a molecule in air it is estimated that each α-particle, of the 80,000 recorded, passes through 100 to 200 thousand atoms, so approximately 10 billion atoms have been shot through, with the result that only three nuclear collisions have resulted in which the initial α-particle has been given a *retrograde* motion. In only one of these (the case cited above) has the collision been direct. A. B. W.

2210. *Lecture Experiment for Isolating Radio-Active Substances by Recoil.* **E. Marx** and **L. Wolf.** (Phys. Zeits. 24. pp. 285–286, July 1, 1923.)—The case of the ionisation chamber is not earthed; but is kept at a constant potential by means of a battery. The inner electrode is connected to one pair of quadrants of a reflecting electrometer, and to a Bronson condenser. An opening in the bottom of the ionisation chamber is closed with aluminium foil, and the plate on which the radio-active substance has been collected is placed below this. If it gives off β-rays, these pass through the aluminium plate, and produce a deflection of the electrometer; the time taken to reduce this deflection to half its original value is observed. H. N. A.

2211. *Study of Forked α-Ray Tracks.* **P. M. S. Blackett.** (Roy. Soc., Proc. 103. pp. 62–78, April 3, 1923.)—The paper is divided into two sections. *Part I*, Range and Velocity of Recoil Atoms. *Part II*, Determination of Mass of Recoil Atoms.

Part I.—Methods have been developed for the analysis of the measurements of α-ray photographs to give the range-velocity relations for four different kinds of recoil atoms (hydrogen, helium, air, and argon). The results yield the rough rule that the range in air of a recoil atom of given velocity is, for velocities between 0·05 and $0{\cdot}10 \times 10^9$ cm. per sec., proportional to the square root of the atomic number of the atom. The ionisation due to the four particles (hydrogen, helium, air, and argon recoil atoms) are compared, and from the comparison rough values of their resultant charges are deduced. The question of the amount of straggling that occurs is discussed, and it is shown that the range variation for particles of given velocity is certainly not more than 15 %.

Part II.—Methods have been developed for making accurate measurements of the angles between the three parts of forked α-ray tracks, that is, of the two angles ϕ and θ. The measurements of the three forks, due respectively to the collision of an α-particle with oxygen, hydrogen, and helium nuclei, are described in detail, and are shown to yield values for the masses of the recoil atoms which agree, with the probable error of the observations, with the normal values. The question of the maximum loss of kinetic energy that could escape detection under the experimental conditions is also discussed. A. B. W.

2212. *Capture and Loss of Electrons by α-Particles.* **E. Rutherford.** (Cambridge Phil. Soc., Proc. 21. pp. 504–510, June 15, 1923.)—By deflecting in a magnetic field a beam of α-particles after passing through mica, Henderson [Abstract 1154 (1923)] has shown that an α-particle in passing through matter occasionally captures one and sometimes two electrons. Henderson's conclusions are now verified and extended by a scintillation method in which $\overset{++}{\mathrm{He}}$, $\overset{+}{\mathrm{He}}$, and He particles are counted individually after deflection of the main beam of α-particles in a magnetic field. The relative number of doubly-, singly-charged, and neutral particles has been obtained by direct counting; and the mean free path of the α-particles for loss and capture of an electron determined for different initial velocities of α-particles. The results are included in the table.

Velocity in Terms of V_0.	λ_2/λ_1 for Mica.	Mean Free Path for Loss in Air.	Mean Free Path for Capture in Air.
		mm.	mm.
0·94	1/200	0·011	2·2
0·76	1/67	0·0078	0·52
0·47	1/6·5	0·0050	0·037

Similar results were observed when the mica was replaced by a gold sheet of equivalent thickness. It is clear from these results that the average α-particle captures and loses an electron several hundred times before absorption. The results, it should be noted, refer to statistical averages for a large number of α-particles, certain observations showing considerable differences between individual α-particles. A. B. W.

2213. *Investigations on X-Rays and β-Rays by the Cloud Method. Parts I and II.* **C. T. R. Wilson.** (Roy. Soc., Proc. 104. pp. 1–24, Aug. 1, and pp. 192–212, Sept. 1, 1923.)—The experiments so far have been confined almost entirely to air. The track of the electron ejected from an atom which emits a quantum of radiation, and that of the electron ejected from the atom which absorbs the radiation, can be identified. The primary action of X-radiation ($\lambda < 0{\cdot}5$ Å.) gives β-ray tracks with initial kinetic energy comparable to a quantum of the incident radiation; and tracks of very short range; the latter electrons are ejected nearly in the direction of the primary X-rays; they are probably related to the phenomena which have led to the postulation of a "J"-radiation. The β-rays frequently occur in pairs, or groups, of which five classes have been distinguished. The pairs probably consist of one K-electron, ejected by the primary X-rays, and a second by the combined action of primary radiation, and of the K-radiation from the atom from which the first electron was ejected. Range measured along track approximately is proportional to 4th power of velocity for ranges of 0·1 cm. to 1·5 cm. Primary ionisation is about 90 per cm. for a velocity of 10^{10} cm. per sec.; it varies approximately inversely as the square of the velocity. Total ionisation per cm. is about 3 or 4 times the primary. Primary ionisation agrees with J. J. Thomson's theory, if the minimum energy of ejection is about 7 volts, approximately the resonance potential (not ionisation) of N. The number of tracks with nuclear deflections over 90° agrees with Rutherford's theory, and gives for the charge of the nucleus $6{\cdot}5e$, almost identical with the actual nuclear charge of $N = 7e$. Many features of the β-ray tracks, including the curvature which sometimes appears, may be due to radiations excited in atoms by the passage of the β-rays; the radiations continually overtaking the β-particle and affecting the subsequent collisions. For other results of the observations the original paper should be consulted. H. N. A.

2214. *γ-Radiation of RaD and RaE.* **Irène Curie** and **G. Fournier.** (Comptes Rendus, 176. pp. 1301–1304, May 7, 1923.)—The following results have been obtained in a series of measurements of the γ-radiation emitted by RaD and RaE in radio-active equilibrium:

	I.	II.	III.
Radiation from	RaD	RaD.	RaE.
Relative intensity (%) of radiation for RaD and RaE in equilibrium	89	9	2
Mass absorption coefficient in aluminium, μ/ρ	16·6	0·37	0·092
Mass of Al per cm.^{2} to reduce the radiation to half-value (grammes)	0·040	1·881	7·526

These results are in good agreement with the work of Rutherford and Richardson [Abstract 94 (1914)], who give the mass absorption coefficients 16·5 and 0·36 respectively for radiations I and II. In addition, the authors have established the existence of the penetrating radiation III attributed to RaE, and have determined its coefficient of absorption in Al. A. B. W.

2215. *α-Particle Tracks in a Magnetic Field.* **P. Kapitza.** (Cambridge Phil. Soc., Proc. 21. pp. 511–516, June 15, 1923.)—The Wilson expansion chamber gives a powerful method of studying the tracks of single α-particles. A study is now described in which the α-particle tracks are affected by a magnetic field, a normally straight track being thereby curved. The radius of curvature at each point of the track is given by $r = vm/eH$, where e and m are the charge and mass of the α-particle, v is the velocity, and H the applied magnetic field. Extremely powerful magnetic fields (of the order 100,000 gauss) of short duration (a few thousandths of a second) were produced by means of a solenoid carrying a very heavy current. Photographs of curved α-ray tracks are reproduced, the curvature being different for each track. The causes of these different curvatures are discussed, and it is suggested that the effects may be due to an asymmetry of the electric field round the helium nucleus. A. B. W.

2216. *Natural Curvature of α-Ray Tracks.* **P. M. S. Blackett.** (Cambridge Phil. Soc., Proc. 21. pp. 517–520, June 15, 1923.)—It has been mentioned by Shimizu [Abstract 148 (1922)] and also by the author [Abstract 514 (1923)] that towards the ends of the tracks of α-rays an appearance of general curvature is noticeable that cannot be resolved by eye into isolated sharp bends. The question arises as to whether this apparent curvature is to be attributed to multiple scattering, that is, to the chance superposition of a number of small bends, or whether some additional mechanism must be postulated. The curvature effect is most marked when the remaining range of the α-particles lies between 0·4 and 2·0 mm., and it is shown that the observed curvatures can be explained very simply by using the theory of scattering given by Thomson [Abstract 1470 (1910)] and Rutherford [see Abstract 1347 (1911)]. It is shown that the average deflection of the α-particles in the last millimetre of their range is of the order of 10° or 20°. This agrees roughly with the measurements.

It is observed also that the curvature is in general away from the initial direction of the track, and it is shown how this can be accounted for by assuming an asymmetry of the α-particle itself. Towards the end of the range this is probable, as the particles remain then usually in a singly charged or neutral state, and only rarely lose both electrons (Rutherford and Henderson). **A. B. W.**

2217. *Colouring and Thermophosphorescence Produced in Transparent Minerals and Gems by Radium Emanation.* **S. C. Lind and D. C. Bardwell.** (Frank. Inst. J. 196. pp. 375–390, Sept., 1923.)—In a previous paper [see Abstract 1427 (1920)] Lind reported some observations on the colouring, decolorisation, and thermophosphorescent effects resulting from the radiation of glass by radium rays. Similar experiments, extended to transparent minerals and gems, are described in the present paper. The subject has already been studied by various investigators. The results recorded here are in the main confirmatory of previous observations, though complete agreement is not to be expected owing to the variations met with from specimen to specimen of the same material. For this reason all results are given, although many of them duplicate those of previous investigations. The minerals used for the observations are as follows: Rock-salt, fluorspar, kunzite, calcite, sapphire, ruby, emerald, topaz, garnet, quartz, glass, obsidian, tourmaline, diamond, chrysoprase, opal and other opaque minerals, aquamarine, zircon, peridote, and moss agate. Various theories are discussed, and it is suggested that the following is a theory of simpler and more general nature than the rest. Certain groups of *electrons* are displaced by radiation from their normal positions and take up new metastable positions among the atoms. No displacement (or only secondary displacement) of the atom is involved. No change in the crystal lattice as revealed by X-rays would be expected, nor would there be any production of colloidal particles. One or more groups of electrons may be involved. By *group* is meant a number of electrons having uniform positions in the original atoms from which they are displaced, and taking after displacement uniform new positions among the other atoms. In cases where two or more groups are involved, the return of one group to the original position may cause thermophosphorescent effects; the return of a different group may cause decolorisation. This does not preclude the possibility that a single group may bring about both phenomena, thus rendering them absolutely coincident. According to this theory, the colour might still be due to the positive ions. It is suggested, however, that it is more probable that colour is due to the vibration of the electrons in their abnormal positions. The influence of impurities is discussed in the light of this theory. Further work on the diamond will be published later. **A. E. G.**

HEAT.

2218. *Mechanical Equivalent of Heat.* **T. H. Laby.** (Nature, 111. pp. 877–878, June 30, 1923.)—A description has previously been given [Abstract 674 (1921)] of an apparatus designed for the accurate determination of the mechanical equivalent of heat. In the early experiments the heat loss was in some cases as high as 2 % of the heat developed. The calorimeter system has now been reconstructed, the "brake" being enclosed in a vacuum flask and the platinum thermometers employed brought close to the flask and highly insulated. Various other improvements have been made, with the result that the heat loss has been reduced to about 0·2 %. Further modifications are being made so as to enable a continuous flow method to be used. A. W.

2219. *Calorimetry of High Explosives.* **R. Robertson and W. E. Garner.** (Roy. Soc., Proc. 103. pp. 539–555, July 2, 1923.)—High explosives, such as picric acid, trinitrotoluene, and amatol 80/20 (80 parts ammonium nitrate, 20 parts T.N.T.) were detonated under definite conditions of confinement and compression. Measurements were made of (1) the heat evolved, (2) the volume of gas produced per gramme of explosive. Analyses of the products of detonation, solid and gaseous, are given in a series of tables. The products found include CO_2, CO, H_2O, H_2, CH_4, C_2H_2, NH_3, HCN, carbon, and in some cases NO_2. The explosive with suitable detonator was closely confined, usually in a "container" in the form of a steel cylinder. The container was held in the middle of a "bomb" of vanadium steel, whose internal volume was about 240 c.c. The bomb was placed in a known weight of water in a calorimeter similar to that described in Roy. Soc. Proc. 99. p. 213, 1921. The total water equivalent of the apparatus was about 3450 calories. The detonator was fired electrically, and the rise in temperature measured by a standardised Beckmann thermometer. The heats of detonation, in calories per gramme of explosive (water gaseous), were found to be: For T.N.T., 926; trinitrophenol, 920; 80/20 amatol, 994 (mean values). The total volumes of gases per gramme were: T.N.T., 711 c.c.; T.N.P., 727; 80/20 amatol, 907. The percentage composition of the gases is dependent on the conditions under which the detonation is carried out, *e.g.* (*a*) Density of loading in the container and in the bomb; (*b*) completeness of detonation; (*c*) purity of explosive; (*d*) nature of the initiator (azide or fulminate); (*e*) degree of tamping of the explosive. The main gaseous reactions which occur during cooling are: (1) $H_2 + CO \rightleftharpoons H_2O + C + 29{\cdot}1$ cals.; (2) $2\,CO \rightleftharpoons CO_2 + C + 39$ cals.; (3) $CO + H_2O \rightleftharpoons CO_2 + H_2 + 10$ cals. From equations (1) and (2) it is evident (as shown also experimentally) that formation of carbon is accompanied by increase in the heat of detonation, and decrease in the volume of gas liberated. Most carbon is formed where density of loading and tamping of the explosive are greatest, this being accompanied by higher pressures. With reference to equation (3), the value of the ratio $(CO)(H_2O)/(CO_2)(H_2)$, the "water-gas constant" was found to vary from about 4·8 to 5·6, which corresponds to a temperature of chilling for this reaction of approximately 1850° C. It is shown, however, that this reaction is probably not the principal one which occurs during the cooling of the gas mixture. When the explosion is incomplete the composition of the products is very different from those of a true detonation. In a partial or slow detonation nitric oxide is formed in large quantity, this gas being characteristic of the decomposition brought about by slow heating of the explosive. T. B.

2220. *The Measurement of Thermal Conductivity.* **E. Griffiths** and **G. W. C. Kaye.** (Roy. Soc., Proc. 104. pp. 71–98, Aug., 1923.)—This paper describes the determination of the thermal conductivity of a large number of poorly conducting materials. The samples tested were in the form of discs, about 45 mm. diameter and of varying thickness up to about 4 mm. Three copper discs were arranged parallel to one another and one sample was sandwiched between the upper copper discs and a similar one between the lower two. The central copper disc was heated electrically and water circulated through the outer coppers. Lateral losses were negligible, the energy input being never greater than 1 % of the heat passing through the sample, as determined from the inlet and outlet temperatures of the circulating water. The apparatus admitted of relatively rapid testing, steady conditions obtaining in from 30 to 45 min. Modifications in the arrangement were made according to the nature of the test. Among the points dealt with in the paper are the thermal resistance at the bounding faces of the material, the measurement of thickness of compressible materials, the dependence of the conductivity of timber on structure and moisture content, the effect of pressure on the conductivity of compressible samples, and the effect of mineral content on the conductivity of rubber. The table gives some of the data obtained, the order of accuracy being about 1 %.

Material.	Conductivity, c.g.s. Units.	
Quartz ⊥ axis	0·0147	
" ∥ "	0·0244	
Ebonite (various samples)	0·00038 to 0·00044	
Vulcanised Fibre	0·0005 to 0·0008	
Mica (various samples)	0·0010 to 0·0014	
Micanite (commercial)	0·0005 to 0·0010	
Cotton fabric	0·00018 to 0·0002	
Silk fabric	0·00010 to 0·00012	
Paper (rice)	0·00011	
Cardboard	0·0004 to 0·0008	
Cement, Portland (burnt)	0·0030	
Commercial rubber (vulcanised)—		
50 % rubber	0·00053	
100 % rubber*	0·00032	
	Mean Conductivity at 20° C.	
Timber†—	‡	§
Ash	0·00042	0·00039
Teak	—	0·00033
Oak	—	0·00028
Balsa	—	0·00011
Fir	0·00028	
Pitch Pine	0·00033	
Kingia Fibre	0·00018 to 0·00025	

* Plantation rubber crêpe.

† Pressure 21 lbs./in.^{2}.

‡ Perpendicular to grain, radial to annual rings.

§ Perpendicular to grain, tangential to annual rings.

L. L.

2221. *Atomic Heats of Cadmium and Tin at Low Temperatures.* **W. H. Rodebush.** (Am. Chem. Soc., J. 45. pp. 1413–1416, June, 1923.)—The author has measured the atomic heats of Cd and Sn over the range 70° K. to 100° K. The method used was similar to that employed by Eastman and Rodebush [Abstract 540 (1918)], except that the apparatus was constructed of metal. The results obtained coincide with the characteristic curve for these metals as obtained by Lewis and Gibson, except for a slight deviation near 100° K. due to the difference between C_p and C_v. Log Θ where Θ is the "characteristic temperature," when $C_v = 3$ is 1·605 for Cd and 1·625 for Sn. These results confirm the accuracy of Dewar's determination between the boiling-points of H and N [Abstract 1968 (1913)] and the entropy calculation of Lewis and Gibson. L. L.

2222. *Principle of a General Method for the Determination of the Thermal Capacity of Solids and Liquids. Application to the Determination of the Water Equivalent of Calorimetric Bombs.* **C. Moureu, C. Dufraisse,** and **P. Landrieu.** (Comptes Rendus, 176. pp. 1513–1515, May 28, 1923.)—Two resistances of equal value are constructed, made of the same metal having the same form, same weight, etc. One of these resistances is placed in one calorimeter in which the solid is immersed in a certain mass of distilled water, the other in a second calorimeter containing a certain quantity of distilled water. The two resistances are placed in series and connected to the same supply. The same elevation of temperature is obtained by varying the quantity of water in the second calorimeter. E. G.

2223. *The Compressibility of Hydrogen to High Pressures.* **P. W. Bridgman.** (Rec. des Trav. Chim. des Pays Bas. 42. pp. 568–571, July, 1923.)—Data on the volume of hydrogen between 2000 and 13,000 kg./cm.^{2} at 30° and 65° C. are given. It is found that hydrogen is forced through the walls of a steel container at a pressure of 9000 kg. In the procedure adopted the hydrogen is compressed initially into a small cylindrical steel bomb at a pressure of 2000 kg. or more. The bomb is closed by a valve opening inward, kept closed after filling by the pressure of the gas within, and is placed in larger steel compression cylinder which is filled with kerosene. Pressure is then produced in the kerosene by driving into the cylinder a leak-proof piston by means of a hydraulic press, and the volume of the hydrogen is determined by comparing the amount of kerosene forced in at different pressures with that admitted when the hydrogen container is replaced by solid pieces of steel. For the relation at 2000 kg., the starting-point in these measurements, use is made of the data obtained by Amagat. The value of PV at 30° C., where V is the volume in cm.^{3} per gramme, rises from 2·43 at 2000 kg. to 8·28 at 13,000 kg., the rate of increase becoming less rapid at the higher pressures. With rising pressure the thermal expansion at constant pressure at first decreases, but at the upper end of the pressure range this trend is reversed until finally the expansion at 13,000 kg. is greater than that at 2000. At 13,000 kg. and 30° C. the density is 0·137, or 1·8 times the value for solid hydrogen at the triple point, while the volume is less than the "b" term of van der Waals' equation. The results indicate that the molecule is itself compressed at these high pressures. Up to 7000 kg. the results are in close accordance with the equation of state of Keyes [Abstract 858 (1917)], but above this value the observed compression is too high. J. N. P.

2224. *The Vapour Pressure of Lead. Part I.* **A. C. Egerton.** (Roy. Soc., Proc. 103. pp. 469–486, Jan. 1, 1923.)—The aim in view was the determination of the difference of the vapour pressures of the isotopes of lead, and high accuracy in the measurements was very necessary for this purpose. The method employed was that of effusion of vapour at high vacuum through a hole of measured area. The amount effused was determined by loss of weight. Temperatures were maintained constant by a resistance thermometer connected with a sensitive relay arrangement in which all mechanical parts were replaced by a light beam which altered the resistance of a selenium cell. Temperature at 800° C. could be maintained constant within 1/3° C. for many hours. Pressures were measured down to 10^{-5} mm., *viz.* at 537° C. A difference of 2 per cent. in the vapour pressures of lead and of uranium lead (at. wt. 206·29) was observed at 700° C., corresponding with no energy term at absolute zero, and agreement with the 3/2 log M law for the chemical constant. The evidence, however, is stated to be inconclusive, and further work is in hand on this point.

The vapour pressure of ordinary lead (molten) at temperatures 1200°–600° absolute is expressed by the equation

$$\log p = 7\cdot908 - 9923/\mathrm{T}.$$

The latent heat of vaporisation of the solid lead at absolute zero is 47,000 ± 1000 cals.

From the vapour-pressure measurements the latent heat of vaporisation of the molten metal varies very little with the temperature up to 1200°, being about 45,350 cals. Determinations of the specific heat are being made in order to further test this point. The chemical constant of ordinary lead from what are considered the most accurate measurements is found to be $1\cdot8 \pm 0\cdot2$, agreeing with the theoretical value 1·853 obtained from $3/2 \log \mathrm{M} - \mathrm{C}_0$, where $\mathrm{C}_0 = 1\cdot622$. Lead is very subject to a lowering of vapour pressure when heated, *in vacuo*, for long periods under the conditions of the present experiments. E. G.

2225. *The Second Virial Coefficient of Gases.* **A. F. Core.** (Phil. Mag. 46. pp. 256–272, Aug., 1923.)—The equation of a gas may be written $pv = \mathrm{A} + \mathrm{B}/v + c/v^2 + \ldots$, where A, B, C, etc., are called the first, second, third, etc., virial coefficients. These coefficients are functions of T, but not of v. The value of A is necessarily RT, the same for the gramme molecule of all non-dissociating gases. In the case of spherically symmetrical molecules, the equation obtained by the aid of statistical mechanics is $pv = \mathrm{RT} + 2\mathrm{RT}\pi\mathrm{N}\sigma^3/3v + 2\pi\mathrm{N}^2\int_\sigma^\infty \chi r^2 dr/v$, where r is the distance between the centres of two molecules, χ the instantaneous potential due to the other molecules, and the remaining symbols have their usual significance. Comparing this equation with that of van der Waals in the form $pv = \mathrm{RT} + \mathrm{RT}/v - a/v$, it is seen that the "$b$" of van der Waals equals $\frac{2}{3}\pi\mathrm{N}\sigma^3$, that is 4 times the actual volume of the molecules in the gramme molecule, and that the "a" of van der Waals equals $-2\pi\mathrm{N}^2\int_\sigma^\infty \chi r^2 dr$. The second virial coefficient "B" is seen to be separated into two parts, one of which is nearly proportional to T, and the other nearly independent of it, just as in van der Waals' equation. The third virial coefficient in the case just taken is found to be $\frac{5}{8}\mathrm{RT}b^2$, where

$b = \frac{2}{3}\pi N\sigma^3$. Extending the reasoning to molecules of a general type, the equation obtained is, at sufficiently high temperatures, $pv = RT + RTb/v - N^2 b\chi_\sigma^2/3RTv$. An expression for the second virial coefficient, B, is also deduced for a binary mixture of gases. T. B.

2226. *Specific Volume of Saturated Ammonia Vapour.* **C. S. Cragoe, E. C. McKelvy, and G. F. O'Connor.** (Bureau of Standards, Sci. Papers, No. 467. pp. 707–735, 1923.)—In the present investigation the specific volume of saturated ammonia vapour was measured in the temperature interval − 50° to + 50° C. by two methods—one involving a direct determination of the mass of the vapour contained in a known volume, and the other, an optical method, involving measurements of the index of refraction of the vapour. In the case of the first method the effect of adsorption was studied and found to be of a magnitude comparable with the limit of accuracy of that method. In the second method a Fizeau-Pulfrich interferometer was used in the measurements of the refractive index, and the Gladstone and Dale relation, $u'(n - 1) = \text{constant}$, was assumed to be correct within 1 part in 1000. The validity of this assumption for the pressures dealt with was well borne out by experiment.

Values for the specific volume were calculated from the Clapeyron equation. The experimental results found by the two methods are in fair agreement with the calculated values above 0° C., differing at most by about 0·3 %. Below 0° C. the results found by the direct method are systematically lower, and those found by the optical method are systematically higher, than the Clapeyron values, amounting to about 2 % at − 50° C. The calculated values were chosen, therefore, as the most probable values. The possible sources of error in the two methods are discussed. The final results are represented closely by the empirical equation :

$$\log_{10} u' = 300\left[\frac{6{\cdot}46344}{\theta} - 0{\cdot}106887 + 0{\cdot}0356803 \log_{10}\theta\right] + 0{\cdot}0862366\sqrt{406{\cdot}1 - \theta} + 0{\cdot}002667(406{\cdot}1 - \theta)$$

in which u' is expressed in cm.³/g. and θ in degrees absolute (° abs. = ° C. + 273·1). [See also Abstract 352 (1922).] E. G.

2227. *Tables of Thermodynamic Properties of Ammonia.* (Bureau of Standards, Circ. No. 142. [48 pp.] 1923.)—Three principal sets of tables are given : (*a*) Properties of saturated fluid ; (*b*) Properties of the liquid ; (*c*) Properties of the superheated vapour.

These tables embody the results of an elaborate series of measurements of the thermodynamic properties of ammonia. The fundamental units and constants used in the tables are defined. The empirical equations used in computing the tables, and also the references to the publications dealing with the experimental data, are given. The tables have been prepared in forms convenient for use in refrigerating engineering. The same data are also presented graphically in the form of a Mollier chart. E. G.

SOUND.

2228. *Vibration of Air in Pipes Closed at Both Ends.* **C. Barus.** (Nat. Acad. Sci., Proc. 9. pp. 263–265, and 266–268, Aug., 1923.)—The closed ends of the various pipes (some of which are **H**-shaped and some of fine bore) are closed by telephone diaphragms. These may be actuated in like or in opposing phases. Graphs are given in which the ordinates denote the fringe displacements of the interferometer **U**-tube and are proportional to the acoustic pressure generated. The abscissæ of the graphs are usually the pitches of the notes used and are plotted as logarithms of the frequencies. Various puzzling features crop up which are discussed, but not entirely cleared up. E. H. B.

2229. *Physical Measurements of Audition and their Bearing on the Theory of Hearing.* **H. Fletcher.** (Frank. Inst., J. 196. pp. 289–326, Sept., 1923.)—The minima pressures of audibility for various pitches from the lowest to the highest audible are experimentally ascertained and plotted. Also the maxima pressures for pure hearing, *i.e.* the threshold of feeling which is the same for the ear as for the finger, are plotted on the same diagram. The area enclosed by these lower and upper curves is called the *auditory sensation area.* Graphs are also given for the minimum perceptible differences in frequency and in intensity. All these graphs give important experimental data for theories of audition. The auditory area is then plotted for various cases of deaf persons and this leads to a mode of defining the *amount of hearing* as follows. The *percentage* of the *total number* of distinguishable pure tones audible to a person with normal hearing that can be sensed by the deaf person expresses his amount of hearing. The *percentage of deafness* is (100 − the percentage of hearing). Six graphs then follow showing from 94 down to 12 per cent. of hearing. The masking of pure tones one by another is then dealt with, graphs being plotted showing how much a given tone must be raised above threshold audibility to make it audible in the presence of a masking tone. Contrary to what was stated by A. M. Mayer (Phil. Mag. 11. p. 500, 1876), it is shown that higher tones may mask lower ones. Many graphs are given of monaural and binaural masking. After reviewing various theories of audition, it is then shown that the facts are accounted for by an amplification of the theory of maximum amplitudes first put forward in definite form by Gray in 1899 (Jour. Anat. Phys. 34. p. 324, 1900). This assumes that the position of maximum amplitude of the basilar membrane varies with the pitch of the stimulating tone. Although a considerable portion of the membrane vibrates when stimulated by a pure tone, the ear judges the pitch by the position of maximum response of the basilar membrane. It is here held to be a strange thing that the phenomenon of the masking of tones, which has been considered by some to be fatal to any resonator theory, is the very thing that has furnished experimental data which makes it possible to calculate the vibration characteristics of the inner ear. These calculations are then discussed and their bearing pointed out. The paper concludes with two mathematical appendices and a classified bibliography of over ninety references. E. H. B.

2230. *Sensibility of the Ear to Small Differences of Intensity and Frequency.* **V. O. Knudsen.** (Phys. Rev. 21. pp. 84–102, Jan., 1923.) —The intensity and pitch sensibilities of the ear as functions of loudness and frequency are measured. The intensity sensibility is defined as $\Delta E/E$ where ΔE is the least perceptible difference of energy and E is the total energy of the tone; similarly pitch sensibility is $\Delta N/N$. The author uses as a source of sound a telephone receiver actuated by a current from a vacuum tube oscillator. The intensity or the pitch can be varied periodically, about once a second, by automatically changing the resistance or capacity in the oscillating circuit. The method of observation is to change ΔE or ΔN continuously until the threshold of perception of fluctuation is reached. Auxiliary experiments showed that the acoustical energy of the source is a linear function of the electrical energy input and the latter is used as a convenient measure of the intensity of the sound. The frequency scale is determined by calibration. The intensity sensibility is found to be about 0·10 for moderate and high intensities, but to increase to the limiting value unity as the intensity decreases to the threshold. The curves are very similar to those obtained for the eye, and the modification of the Weber-Fechner law proposed by Nutting for light sensation fits the results, $\Delta E/E = F + (1 - F)(E_0/E)^n$, where E_0 is the threshold intensity and F is about 0·10. The exponent n varies somewhat with the frequency, being 1·65 for 200 d.v. and 1·05 for 1000 d.v.; nevertheless at the same loudness level, *e.g.* 10,000 E_0, $\Delta E/E$ is nearly independent of the frequency, showing only a 10 % variation from 100 to 3200 d.v. The results are the same whether harmonics are present or not. It is concluded that for 1000 d.v. under favourable circumstances the normal ear can distinguish about 400 gradations of loudness between the threshold and a painful intensity 10^{12} times as loud. As regards pitch, sensibility for the same loudness level $\Delta N/N$ decreases from 0·01 at 50 d.v. to 0·003 at 600 d.v., and then remains constant up to 3200 d.v. The limit of perception of variation of pitch is about the same for trained as for other ears, but training helps in distinguishing which note is higher. Two ears are found more sensitive than one to small differences of pitch but not to small differences of loudness. T. H.

2231. *Correlation between Physical and Medical Findings on Normal Ears.* **J. P. Minton** and **J. G. Wilson.** (Nat. Acad. Sci., Proc. 9. pp. 269–274, Aug., 1923.)—Fifty-four cases are examined physically and medically and the agreements are satisfactory. The graphs given of these cases coordinate the minimum audible pressures in dynes acting on the ear drum against the frequencies, which range from 64 to 500 complete vibrations per second. Many cases exhibit specially poor sensitiveness (shown by deep troughs in the graphs) at or near 2000 and 4000 per second. [See Abstract 183 (1923).] E. H. B.

V.2
192

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

2232. *Magnetic Fields due to Circular Currents.* **T. J. I'A. Bromwich.** (Phil. Mag. 46. pp. 108–112, July, 1923.)—Referring to H. Nagaoka's investigation of these fields by means of *q*-series [Abstract 1589 (1921)], the author points out that Nagaoka's formulæ can be obtained in a very elementary way by using Legendre's theorem that the potential of a symmetrical system can be determined when the form of the potential is known along the axis of symmetry. The author works out in detail by this method the solutions for the field of a single circle and of the field near the centre of Helmholtz's double coil galvanometer. The formulæ so obtained are identical with those obtained by Nagaoka, except for what appears to be an error in the coefficient of ρ^6 in his solution of the single circle problem. G. W. DE T.

2233. *Electric Fields due to Motion of Constant Electromagnetic Systems.* **W. F. G. Swann.** (Phil. Mag. 45. pp. 1191–1192, June, 1923.)—This is a reply to some criticisms by S. J. Barnett of a recent paper by the author [see Abstract 720 (1923)]. G. W. DE T.

2234. *Stress System of Four-Dimensional Electromagnetic Field.* **S. R. Milner.** (Phil. Mag. 46. pp. 125–128, July, 1923.)—In a recent paper [Abstract 69 (1923)] the author has shown that, in certain respects, the general electromagnetic field considered as a fourfold entity appears as the natural extension to four dimensions of the threefold electrostatic field. Here it is shown that the stress system of a fourfold electromagnetic field forms another respect in which a similar exact equivalence holds with the electrostatic field in three dimensions. He then considers, in the general electromagnetic field in four dimensions, the tensor given by Sommerfeld [Abstract 1215 (1910)] as the most general symmetrical tensor product determinable from the two six-vectors of the electromagnetic field $(\mathbf{h}, -i\mathbf{e}), (-i\mathbf{e}, \mathbf{h})$, and proves that the general electromagnetic field in four-space with imaginary time may be regarded as being in statical equilibrium under the action of the stress system determined by this tensor. Where F_x, F_y, F_z, F_l are the components of the resultant face along the four axes per unit hyper volume on an element $dxdydzdl$, real time now being taken, the equations $F_x = F_y = F_z = 0$ express the well-known theorem that the time rate of increase of the momentum of a space element of the field is equal to the resultant of Maxwell's electromagnetic stress on it, while $F_l = 0$ expresses that the rate of increase of the energy density at a point is equal to the convergence there of Poynting's energy flux. Even with real time the equations may also be regarded as the expression of the static equilibrium of a fourfold system of stress, the formulæ being the direct extensions of those of the threefold system when allowance is made for the different geometry of the space-time in the T direction. The result is accordingly implicitly contained in the formulæ for the tensor in general relativity theory. [For a discussion of the general properties of the tensor see Eddington, "Math. Theory of Relativity," p. 182, 1923.] G. W. de T.

2235. *Motion of an Electrical Particle in a Riemann Space.* **A. Bramley.** (Nat. Acad. Sci., Proc. 9. pp. 289–291, Aug., 1923.)—The author assumes Eisenhart's equations of motion of a charged particle (these Proc. 9. pp. 175–178, 1913). The law of force is shown to be that of Coulomb, and it is found that an infinitesimal particle revolving about a fixed charge, say, an atomic nucleus, must describe a definite circular orbit with constant velocity. The analysis applies only to an infinitesimal particle, but will probably apply in the case of the orbit of an electron about the nucleus. The method employed is not applicable to radiating electrons. G. W. de T.

2236. *The Einstein Field Equations for an Arbitrary Distribution of Matter.* **T. Y. Thomas.** (Nat. Acad. Sci., Proc. 9. pp. 275–278, Aug., 1923.)—The author supposes the trajectories of the motion of a mass particle in a gravitational field to be given by the equations assumed by Einstein, and the metric structure of the space-time to be that derived from the Schwarzschild solution of the field equations. He so obtains a solution in rectangular coordinates for the gravitational field produced by any stationary distribution of matter. But it does not satisfy the field equations, "although it is exactly the form that we must have if a solution of the general case is to exist which is of the same nature as the Schwarzschild solution for a single particle." A solution which does satisfy the field is obtained, but only on the condition that: In an infinitely small space-time region of the gravitational field a coordinate system can be selected with reference to which space possesses a Schwarzschild structure. This will be the case only if a certain infinite set of tensor equations are algebraically consistent. G. W. de T.

2237. *Illustrations of Electric Displacement Currents.* **J. S. Ames.** (Frank. Inst., J. 195. pp. 787–798, June, 1923.)—The general theorem is developed that if there be any distribution of charges, ρ, σ, or e, which has a uniform velocity v, the displacement current-density produced thereby is indentically the same as the displacement due to a stationary polarised distribution formed by associating with ρ/a, σ/a, or e/a charges of opposite signs at a distance av in a direction opposite to that of the original motion. This fact enables the lines of the displacement current-density to be immediately drawn, if the corresponding lines of displacement are known. The cases (*a*) where a charge e has a velocity v along the axis of X; (*b*) where a doublet of strength M has a velocity $\bar{v}$ in the direction of its axis; (*c*) where an uncharged dielectric or conducting sphere moves with a velocity $\bar{v}$ in and parallel to a uniform field of force; (*d*) where a doublet of strength M has a uniform velocity $\bar{v}$ at right angles to its axis, are analysed with graphical representation by way of illustration. A. B. C. L.

2238. *Comparative Considerations on the Dimensions of Electrical Units.* **A. Forster.** (Schweiz. Elektrot. Verein, Bull. 14. pp. 445–450, Aug., 1923.)—Proceeding from the principle of the equivalence of energy in its various forms, the author determines in a simple manner the dimensions of the ordinary electrical and magnetic units and makes a comparison between them and the dimensions of mechanical units. H. H. Ho.

2239. *On the Arborescent Effects Produced by the Positive Discharge.* **A. Lafay.** (Comptes Rendus, 177. pp. 28–30, July 2, 1923.)—When a mixture of sulphur and red lead is projected on to a plate of insulating material strongly electrified by a positive discharge, arborescences appear. The application of methods previously described [see Abstracts 1810 and 1811 (1921)] permits it to be established that the mode of transport of the charges which produce these characteristic ramifications differs from that of the particles constituting the rest of the discharge, these latter behaving as positive ions weighted by an assemblage of molecules. Section I of the paper describes various designs which are produced. Section II discusses the speed of the constituents of the discharge as measured by the author's method [*loc cit.*]. Section III indicates an arrangement for investigating the effect of magnetism on the phenomenon. A field of 6000 gauss acting upon jets 12 cm. long gave no appreciable displacement. Section IV discusses the formation of branches and then states that when the insulator plate is replaced by one of metal only patches are formed whose edges are light and rounded and exhibit no trace of ramification. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

2240. *Discharge at High Frequency in Rarefied Gases.* **C. Gutton, S. K. Mitra, and V. Ylostalö.** (Comptes Rendus, 176. pp. 1871–1874, June 25, 1923.)—When for researches on damped Hertzian oscillations tubes of rarefied air are used, it is found that the pressure for which the passage of the discharge is easiest is much higher than at low frequency. For the same pressure the appearance of the tube is entirely different. The tube with 3 electrodes permits of oscillations of constant amplitude and very high frequencies, and the present investigation relates to the variation of the difference of potential between electrodes for which the tube becomes luminous when the frequency of this potential difference and the gas pressures are changed. The experiments have been made between the frequencies 50 and 2,140,000, corresponding to 140-m. wave-length. Experimental details are given very fully with data tables. When the pressure is increased the difference of potential is found to decrease rapidly at first, to pass through a minimum value and then to increase. Results are described for internal and external electrodes these differing markedly from each other. H. H. Ho.

2241. *Ionisation of Nitrogen by Electron Impact.* **H. D. Smyth.** (Roy. Soc., Proc. 104. pp. 121–134, Aug. 1, 1923.)—In a previous paper [see Abstract 736 (1923)] the author suggested a new mode of attack on some ionisation problems and described its application in experiments on mercury-vapour. The object of the method is to give a direct means of studying the types of ion produced in a gas or vapour by electrons of known speed. The experimental principle involved is the combination of an ordinary ionising potential apparatus with an arrangement for positive-ray analysis. A schematic diagram representing the general electrodes and electric fields in both types of apparatus used for nitrogen is given. The second apparatus is drawn to scale. The essential improvement is that the ionisation chamber is shut off from the region where the positive ions are accelerated by the platinum foil electrode which has only a small slit enabling a beam of positive ions to pass through it. Nitrogen was prepared by the reaction of bromine and ammonia as described by Waran. It was stored over P_2O_5. The results obtained on nitrogen show that the ordinary ionising potential at 16·9 volts corresponds to the production of singly charged molecular ions, that doubly charged atomic ions appear at 24·1 ± 1·0 volts and singly charged atomic ions at 27·7 ±0·8 volts. These results are explained as corresponding to the transitions $N_2 \longrightarrow N_2^+$, $N_2 \longrightarrow N_2^{++} + N$ (or N^-) and $N_2 \longrightarrow N^+ + N^+$. This leads to values of 11 and 18 volts for the first and second ionising potentials of atomic nitrogen. Further results at higher voltages show the variation of the relative intensity of the different types of ion with voltage. In particular, there is a very sharp increase in the proportion of atomic ions between 350 and 400 volts, corresponding roughly to the K-limit of 375 volts found by Foote and Mohler. It is hoped that as the experiments on other gases are continued the results at high voltages can be made more precise and enough material accumulated to throw some light on the mechanism of ionisation as well as molecular structure. Experiments on hydrogen are in progress. A. E. G.

2242. *Motion of Electrons in Gases.* **V. A. Bailey.** (Phil. Mag. 46. pp. 213–218, July, 1923.)—A large number of investigations have been made of the motion of electrons in gases, and it seems desirable to point out what reliable information may be obtained from the experiments, as the present generally accepted views of the behaviour of electrons in gases at the higher pressures and under low forces are to a great extent unsatisfactory. Too frequently the results of different experimenters do not agree with one another, or are obtained by a wrong interpretation of the observations; while in many cases the methods used are fundamentally unsound. Methods for measuring W, the velocity in the direction of the electric force, have been devised by Rutherford, Langevin, Zeleny, Chattock, and Townsend; these are discussed briefly, as are also the special cases of Lattey and of Franck. The evidence of the possible existence of free electrons in a gas was obtained by Townsend in the course of determinations of the quantity Ne for different gases. The experiments of Townsend and Tizard established that in very dry air the free electronic state exists when X/p exceeds the value 0·2 and the more recent experiments on very dry N_2, H_2, A, He, and CO_2, give similar results. It is concluded that the Franck's form of the Rutherford method is in general quite unsuitable for the study of the motion of electrons. Lattey's form of the method, however, is much less open to criticism, and fails to give accurate results only when the effects of diffusion become appreciable; but the method was originally designed for measuring the velocities of ions and cannot be easily adapted to measure the higher velocities of electrons.

A rough general outline of the present state of knowledge about the motion of electrons in gases with low values of X/p is given. [See also Abstract 970 (1922).] A. E. G.

2243. *The Emission of Secondary Electrons from Nickel.* **E. W. B. Gill.** (Phil. Mag. 45. pp. 864–878, May, 1923.)—The curves of Figs. 1 and 2 were obtained with a Marconi M.T. 5 valve, the vacuum being very low. Suppose that electrons leave the grid with zero velocity; grid potential = + V_G; V_P plate potential and filament potential = 0. If all the electrons moved in straight lines after passing the grid, they would just reach the plate with zero velocity. The paths are bent, as they pass through the grid spaces, and they nearly all return to the grid in curved paths. Let *v* be the potential at the point where an electron, which has passed very near the grid wire, begins to turn back towards the grid; then if the plate potential is gradually raised from 0 to *v* the number of electrons reaching the plate will increase, rapidly at first and then slower and slower, until *v* is reached. The value of *v* depends on V_G, and if V_G is increased a larger plate voltage is necessary to bring all the electrons to the plate. In Fig. 2, with $V_G = 10$, a small value of V_P, probably about 1 volt will produce primary saturation at the plate. If there were no secondary emission the current would remain constant when V_P was increased above about 1 volt. The curve shows that secondary emission has become appreciable when the primary electron has fallen through about 1·5 volt, though the amount is small. Thus there will always be secondary emission for $V_P = 1{\cdot}5$ whatever V_G may be. The curves also show that for higher values of V_G, when V_P is increased beyond 1·5, more primaries reach the plate, and the current continues to grow because the number of primaries collected more than compensates for the secondaries leaving the plate. Thus the maximum is shifted to the right as V_G increases. The slight difference between the shapes of the curves when they slope downwards to the right is explained by the fact that more secondary electrons are produced with oblique impact than with direct impact; an increase of V_P leaves the incidence more oblique with $V_G = 400$ than with $V_G = 200$, and so the emission increases more in the first case than in the second. The final rise of the curves, when V_P approaches V_G, indicates that very few secondaries then reach the grid. To explain this the author considers the field more in detail, and finds that as V_P is raised the field near the plate weakens and reverses for values of V_P *less* than V_G. The secondaries produced will then be drawn back to the plate. H. N. A.

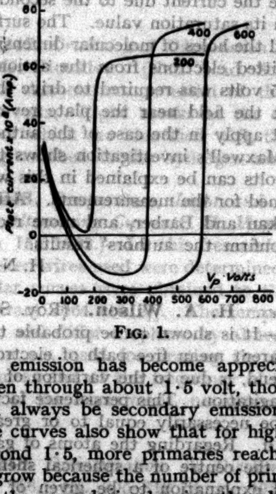


FIG. 1.

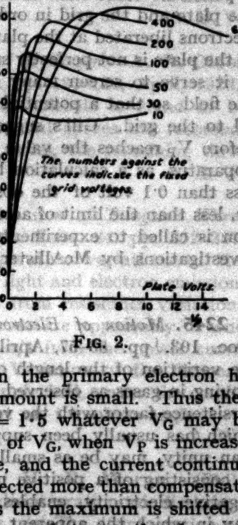


FIG. 2.

2244. *The Emission of Secondary Electrons from Metals under Electronic Bombardment.* **F. Horton and A. C. Davies.** (Phil. Mag. 46. pp. 129–

134, July, 1923.)—A reply to criticisms of a previous paper made by E. W. B. Gill [see preceding Abstract] on the authors' investigations of the effect of electron collisions with platinum and with hydrogen. The authors still hold the view that the sharpness of the downward bend after the first maximum of the plate current has been attained [this refers to the curve as shown in Gill's paper] indicates the commencement of a new effect when the velocity of impact reaches this particular value. A similar result was obtained by H. E. Farnsworth with a bombarded nickel plate. The three electrode Marconi valve used by Gill was not suitable for the investigation, as, when the grid potential is kept constant and that of the plate increased, there may be a marked increase in the proportion of the electrons leaving the filament which reach the plate, owing to the imperfect shielding action of the grid; the authors' apparatus was constructed so as to avoid this, and any defect in the screening action is very much smaller than in Gill's valve. The authors think it not at all improbable that a difference of potential of a few volts is required between the plate and the grid in order to cause the current due to the secondary electrons liberated at the plate to reach its saturation value. The surface of the plate is not perfectly smooth, and the holes of molecular dimensions in it serve to screen many of the emitted electrons from the action of the field, so that a potential of about 5 volts was required to drive them all to the grid. Gill's suggestion that the field near the plate reverses before V_P reaches the value V_G cannot apply in the case of the authors' apparatus, as a calculation based on Maxwell's investigation shows that less than 0·1 volt of the observed 5 volts can be explained in this way, *i.e.* less than the limit of accuracy claimed for the measurements. Attention is called to experiments by Millikan and Barber, and more recent investigations by McAllister, which confirm the authors' results.

H. N. A.

2245. *Motion of Electrons in Gases.* **H. A. Wilson.** (Roy. Soc., Proc. 103. pp. 53–57, April 3, 1923.)—It is shown to be probable that the variation of the length of the apparent mean free path of electrons, moving in gases as observed by Townsend, is due to the variation of the persistence factor with the velocity of agitation. This persistence factor, which has usually been supposed to be necessarily equal to or greater than unity, may be as small as one-half. Regarding the atoms of gases as consisting of a positive nucleus at the centre of a spherical shell of negative electricity, enables a general explanation to be given of the way in which the apparent mean free path of electrons varies with the energy of the electrons in nitrogen and hydrogen. A. B. W.

2246. *Theory of Abnormal Kathode Fall.* **Research Staff of General Electric Co., London.** (Phil. Mag. 45. pp. 1149–1155, June, 1923.)—A theory of the abnormal kathode fall in vacuum tubes is given, according to which conduction in the dark space is closely analogous to that in a high vacuum between a plane thermionic kathode and plane anode. According to the theory, the width of the dark space with given current and voltage should be determined by the atomic weight of the gas and universal constants. The theory is compared with the measurements of Aston and of Aston and Watson. [Abstract 1072 (1907) and Abstract 915 (1912)]. The relatively small divergence between the simple theory and experiment can be removed by taking into account the electrons liberated

V.
19

at the kathode, information concerning which is given by Cheney's measurements [Abstract 95 (1918)], and the collisions of the positive ions with neutral molecules. It appears to be difficult, however, to reconcile the theory with Aston's determination of the variation of the electric field through the dark space.

Remarks by **F. W. Aston** (*ibid.* 46. pp. 211–213, July, 1923) on the above paper. The author is entirely unable to accept Ryde's view that the simple theory is adequate even for a preliminary survey of the facts. For example, the theory does not distinguish between N_2 and CO (having the same mass); again, experiments show no measurable voltage-difference between the metal of the anode and the edge of the negative glow, whereas 130 volts is required by the curves shown in Ryde's paper. In conclusion, he expresses the opinion that the true solution of all the perplexing discrepancies is probably to be sought for in the fact that the positive ions moving rapidly through a gas do not retain their identity, but gain and lose electrons the whole time as they collide with other particles.

A. B. W.

2247. *Critical and Dissociation Potentials of Hydrogen.* **A. R. Olson** and **G. Glockler.** (Nat. Acad. Sci., Proc. 9. pp. 122–126, April, 1923.) —The dissociation potential of the hydrogen molecule is found to be 3·16 volts. Eight breaks in the current-potential curves are recorded, five of which are identified with the Lyman series, the remaining three being ascribed to the hydrogen molecule. A. B. W.

2248. *Temperature, Light, and Electron Emission of Tungsten Wires with Alternating Current.* **H. Hunkel.** (Phys. Zeits. 24. pp. 252–257, June 15, 1923.)—In this research the temperature variations of the tungsten wires used were determined from the light and electron emission. Similar curves were obtained to those found from resistance variations [Abstract 1064 (1912)]. The temperature curves are apparently of sine form, and differ in phase by almost exactly $\pi/4$ from the power curve of the a.c. used for heating the filaments. Variation of the filament thickness and of the frequency of the a.c. supply had, under the conditions of the experiment, no appreciable effect on the phase-angle.

A. W.

2249. *Disintegration in Discharge Tubes.* **H. P. Waran.** (Phil. Mag. 46. pp. 305–312, Aug., 1923.)—The disintegration of discharge tubes may be divided broadly into two classes: (*a*) The disintegration of the electrodes known as the sputtering; (*b*) the disintegration of the glass walls. A good deal of work has been done on the first [for the most recent see Abstract 727 (1923)], but very little is known about the disintegration suffered by the glass walls, probably for the reason that its effects are not so very marked. As in the case of kathodic sputtering, the agency responsible for the observed effect is mainly the ionic bombardment of the walls. Such a bombardment may bring about the disintegration either mechanically or thermally, or by a combination of both actions. The effect of the positive ions is discussed and the evidence in support of a mechanical origin is briefly summarised. In dealing with the observed tracks on the tube walls the question of energy is considered, and as a result it is concluded that though it is possible that the positive ion-bombardment may be indirectly assisting the formation of such markings the marks themselves can never be regarded as the tracks left by the motion of the positive particles along the walls. An interesting property of these marks is their regularity and symmetry of distribution along the axis of the tube, a property displayed also by the striations, and it seemed possible that there might be some connection between the two. Quincke by his extensive researches on the thermal properties of glass has shown that in the neighbourhood of an electric discharge the localised heat might be sufficient to melt a superficial layer of glass, and on its subsequent solidification and cooling superficial fractures are developed. Such a thermal view of the phenomenon seems to be quite applicable to the type of disintegration under discussion even when the potential used to excite the tube is comparatively low. A. E. G.

2250. *On a certain Family of Periodic Solutions of Differential Equations, with an Application to the Triode Oscillator.* **W. M. H. Greaves.** (Roy. Soc., Proc. 103. pp. 516–524, June 1, 1923.)—Appleton and van der Pol gave the differential equation for the anode potential of a triode oscillator, and Appleton and Greaves have given solutions of it [see Abstract 1202 (1923)]. In the present paper the author investigates the generalised formula and discusses the convergence of the series obtained. The relation of the work to the theory of periodic solutions developed by Poincaré is discussed. G. W. O. H.

2251. *The Magnetic Field due to a Thermionic Valve.* **K. Basu.** (Calcutta Math. Soc., Bull. 13. pp. 191–200, March, 1923.)—The electrons passing from filament to anode constitute a current and produce a magnetic field. Formulæ are developed for this field and are found to be of a type well known in Hydrodynamics. G. W. O. H.

2252. *The Ambiguity of the Spark Discharge.* **Y. Niwa.** (Inst. El. Eng. of Japan, J. No. 416. pp. 262–265, March, 1923.)—The term "ambiguity" refers to the fact that the sphere gap sometimes discharges and sometimes fails to discharge under the same conditions of impulse circuits. This has been shown by Bekku and Tanno by means of experiments conducted with spheres of 1·0 cm., 3·8 cm., and 6·25 cm. diameter. The author suggests that the phenomena may be explained by "casual ions" in the air. W. R. C.

2253. *Gradient of Potential near Electrodes.* **S. Pieńkowski.** (Nature, 112. p. 99, July 21, 1923.)—H. Nagaoka and V. Sugiura have previously described a method of observing the Stark effect in the iron arc, namely in the thin layer at the surface of the lower electrode. This fact points to the existence of a considerable gradient of potential in the layer. The present author, by means of direct electric measurements, has found the existence of a considerable gradient of potential in the thin layer that surrounds the electrodes when the sparking discharge takes place. The discharge of 952 sparks per sec., yielding an effective current of 24 milliamps, shows that the change of the difference of potential depends upon the length of spark. If the sparks are so short that the thin layers in the proximity of the electrodes, which yield a metallic spectrum, are not yet divided, then there exists a great gradient of potential. These facts are shown by plotting difference of potential against length of spark. The size of gradient depends first upon the nature of the metal forming the electrodes. At longer sparks, while among the above-mentioned layers only a spectrum of gas appears, the gradient of the potential is much less, and this does not depend upon the nature of the electrodes. If V_1 signifies the p.d. for short sparks and V_2 for long sparks, then for Pt and Al electrodes

$$(\text{grad. } V_1/\text{grad. } V_2)_{\text{Pt}} \doteq 10 \qquad (\text{grad. } V_1/\text{grad. } V_2)_{\text{Al}} = 5 \text{ about.}$$

The thickness x of the layer where there is a considerable gradient of potential is small: Pt $x = 0{\cdot}4$, Cu $x = 0{\cdot}4$–$0{\cdot}5$, Al $0{\cdot}7$–$0{\cdot}9$ mm. This investigation is being continued. A. E. G.

2254. *The Mechanism of the Electric Arc.* **W. G. Duffield.** (Phil. Mag. 45. pp. 1139–1148, June, 1923.)—The theory propounded by the author to explain the repulsion experienced by the poles of the electric arc has recently been under discussion and the present paper is the result. The origin of the forces upon the poles is discussed under three headings: (1) The motion of ions under the electric forces in the arc; (2) the evaporation of carbon atoms from the poles; (3) the relationship between the manometric and mechanical pressures. It is submitted that in the present state of our knowledge the evidence is against the evaporation of carbon being the main cause of the phenomenon, though it may not be quite negligible. Indeed, in the particular state of the iron arc which the author characterises as turbulent, as distinct from the normal quiescent arc, it is thought to play the predominant part. Even in the case of the carbon arc, more exact information regarding the sizes of the hot spots might cause a revision of conclusions. It is suggested that Tyndall's main objection to the theory arises from a misapprehension, the author's argument deals with what takes place *at* or *in the immediate neighbourhood* of the kathode, while Tyndall's objection is based on what takes place *in the body of the arc.* The deductions made by Tyndall and Beer from their experiments is also criticised [see also Abstract 202 (1923)]. A. E. G.

2255. *Repulsion Effect between the Poles of an Electric Arc.* **H. M. Barlow.** (Phil. Mag. 46. pp. 112–114, July, 1923.)—The projection of particles across the gap and the so-called electric wind may have an influence on the forces between the electrodes, but the "pinch effect" is also an important factor. A conductor may be regarded as a large number of filaments parallel to the axis, each carrying part of the total current. All, except the one on the axis, experience a force tending to urge them towards the centre; hence, if the conducting column is mobile it will contract so as to diminish in cross-section and increase in length. If it cannot increase in length the hydrostatic pressure will become greater along the axis than near the surface. The intensity of the pressure p at any radius r is given by $p = I^2(R^2 - r^2)/\pi R^4$ where I = total current and R = external radius of the conductor. If the conducting column of the arc is cylindrical and contracts uniformly, $F = I^2/2$, where F is the force on each pole due to pinch effect. The author concludes that a measurable part of the repulsion effect in an arc is due to the pinch phenomenon operating in the gaseous conducting column between the poles. T. C. H.

2256. *Potential Measurements on a Tesla Transformer.* **M. Wolfke.** (Phys. Zeits. 24. pp. 249–251, June 15, 1923.)—A Braun tube was used to determine the magnitude of the voltage obtained from a Tesla transformer. The voltage was calculated from the magnetic deflection of the kathode rays due to the applied potential. The Tesla transformer primary had 10 turns 32-cm. diameter of thick wire. The secondary, 11 cm. diameter and 75 cm. long, was wound on a glass tube and had 1700 turns of fine wire. The primary was supplied from the secondary of a 2·5-kw., 6000-volt transformer, and a rotary quenched spark was inserted in this circuit, a battery of Leyden jars being used across the transformer terminals. With one end of the Tesla transformer secondary connected to earth, the potential reached at the other end was found to be about 400,000 volts, corresponding to a kathode-ray velocity of about 87 % of that of light. In these measurements the highest power of the Tesla transformer was not reached, owing to the development of brush discharges. A. W.

2257. *Joining the Infra-Red and Electric Wave Spectra.* **E. F. Nichols** and **J. D. Tear.** (Nat. Acad. Sci., Proc. 9. pp. 211–214, June, 1923.)—The electric wave receiver used was a modified form of the Nichols' radiometer; the usual blackened vanes were replaced by heater elements made of very thin deposits of bright metallic platinum on thin mica strips; when electric waves fall on this they cause oscillating currents of the same frequency in the platinum surfaces, and part of the energy is converted into heat. This type of receiver proved to be 100 or more times as sensitive as any quantitative receiver previously used for short electric waves. The oscillator was in principle the familiar Hertzian doublet, with minute tungsten cylinders. A Boltzmann and a Fabry Perot interferometer, and a wholly new form of reflecting echelon analyser were employed in wave-length measurements. The latter gave the approximate wave-form, and accurate wave-lengths. Waves were measured from Lampa's and Möbius' limit of 7 mm., down to 0·220 mm., or shorter than the longest known heat waves. The electric receiver has been used in two different forms to remeasure Rubens' and von Baeyer's 0·320-mm. heat waves, with results agreeing with theirs.

H. N. A.

2258. *On the Mercury Arc as an Audio-Frequency Oscillator.* **Y. Watanabe.** (Tôhoku Univ. Technol. Reports, 3. 2. pp. 7–28, 1923. In English. Inst. El. Eng. of Japan. J. No. 410. pp. 681–693, Sept., 1922.)—The author describes an experimental study of a new mercury-arc method of producing sustained oscillations of audio-frequency. The apparatus is somewhat of the type of Vreeland's oscillator, but a magnetic field excited by a continuous current is necessary, and the principle is entirely different. Instead of the method being electrical it may be described as a purely mechanical oscillation of positive ions between the anodes and a cloud of positive ions. This cloud seems to be formed by the action of the magnetic field. The field deflects the two arc-streams so as to bring them together at a point near the mercury pool. W. R. C.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2259. *Electric Conduction: Hall's Theory and Perkins' Phenomenon.* **E. B. Wilson.** (Nat. Acad. Sci., Proc. 9. pp. 135–140, April, 1923.)—

A brief survey of present-day theories of electric conduction, with particular reference to theories of Hall and Perkins. [See Abstracts 1934 (1921) and 206, 364, and 1210 (1923).] A. B. W.

2260. *The Quasi Equation $P = TdV/dT$.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 9. pp. 207–211, June, 1923.)—If two large plates of different metals are connected each to a wire of like metal, and the two wires are joined, a minute "engine" introduced into the circuit of one of the wires may, with an infinitesimal e.m.f., transfer a unit of positive electricity from A to B, without making any appreciable change in the potential of the plates. If T is the temperature, the heat absorbed $= TdV_{AB}/dT$, where V_{AB} = (Volta potential of B) − (Volta potential of A). This includes the Peltier effect P_{AB} at the junction, and if there is no other heat absorption, $P_{AB} = TdV_{AB}/dT$. Compton found the temperature coefficient about fifty times as large as it should be if this is correct. Lorentz and Kelvin admitted the possibility of a surface thermal effect; and the author has already suggested that this can be accounted for by an application of the mass law of chemical equilibrium to the relations of the free electrons and the positive ions of the metals. If q electrons are taken from one plate we cannot have mass law equilibrium in this metal until sufficient new ionisation occurs therein to make the total number of free electrons in it only 0·5 q less, and of + ions 0·5 q more than at first; in the other metal reassociation takes place, until the number of free electrons is 0·5 q more and of + ions 0·5 q less than before. Practically we may regard the ionisation and reassociation as taking place at the surfaces only. When 1 unit of + electricity passes from A to B, $1/e$ electrons pass from B to A, $1/2e$ electrons are released on the surface of A (iron), and $1/2e$ enter into atomic unions on the surface of B (nickel); the ionising potential has been found to be about 0·398 in iron and 0·144 in nickel at 40° C., thus the work done is that of raising $1/e$ electrons through a potential of (0·398 − 0·144)/2 or 0·127 volt. According to Bridgeman the Peltier effect is equivalent to raising $1/e$ electrons through about 0·011 volt, this added to the above gives 0·138 volt. Compton's experiments give 0·516 volt for the same temperature, or about four times the above; this is certainly better than fifty times, as when the Peltier effect alone is considered. It is possible that the ionisation potentials are considerably greater at the surface of the metals than those given above, as is the case with metallic vapours. H. N. A.

2261. *The Hall Effect of Palladium Charged with Hydrogen.* **P. Raethjen.** (Phys. Zeits. 24. pp. 278–279, July 1, 1923.)—These measurements were undertaken to show how the change in resistance of palladium charged with hydrogen, which rises up to 1·7 fold [see Abstract 1615 (1906)], may be ascribed to influence on the electronic paths and on the number of free electrons. According to theory the constant R of the Hall effect is inversely proportional to the electronic density but independent of the free path, so that this effect is very suitable for the purpose in hand. Brief experimental details are included. It would seem that the alteration of specific resistance is chiefly a consequence of the shortened free paths due to hydrogen atoms present in the spaces of the palladium lattice. This is unfortunately incompatible with Holmes' thermal results, and further experiments by Heimburg point to a smaller electronic density in uncharged palladium, a result incompatible with the decline of the Hall constant by 20 % for the charged palladium. The consequences of the Drude electronic theory appear, therefore, inapplicable to this case. H. H. Ho.

2262. *Thermoelectric Power of Alloys.* **H. Pélabon.** (Comptes Rendus, 176. pp. 1305–1307, May 7, 1923.)—The thermoelectric power of alloys varies considerably with their composition. By means of the apparatus previously described it is possible to study these variations within large ranges of temperature [see Abstract 1324 (1920)]. Results are tabulated, giving the thermoelectric powers of various alloys of Pb-Sb and Su-Bi, taking platinum as the standard of comparison. If further information is required, the original paper should be consulted. A. B. W.

2263. *Dielectric Hysteresis and Allied Phenomena. Part II.* **H. Saegusa.** (Tôhoku Univ., Sci. Reports, 11. pp. 463–469, Dec., 1922.)—In English.)—In continuation of previous work [see Abstract 1905 (1922)] the author has investigated the dielectric hysteresis and allied phenomena exhibited by crystals of fluorite, tourmaline, barite and scheelite. The results indicate that the residual charge in the case of tourmaline is very large and attains a stationary value after an initial rapid increase, followed by a decrease of value. With increase in the time of discharge, the residual charge of tourmaline increases slowly and tends to a saturation value as in normal cases. The limit potential is small. In the case of a crystal of the tetragonal system (*e.g.* scheelite), the time effect, residual charge and hysteresis are much smaller than the values characterising crystals belonging to the hexagonal, isometric and orthorhombic systems, whilst the limit potential is greater in the former than in the latter systems. Dielectrics having a large time effect, large residual charge and a small limit potential are characterised by a large hysteresis loop, the form of which is different for various crystals. Stationary hysteresis exhibited above the limit potential is, in general, larger than the plastic hysteresis exhibited by the crystal. J. S. G. T.

2264. *Variation with Frequency of the Power Loss in Dielectrics.* **H. J. MacLeod.** (Phys. Rev. 21. pp. 53–73, Jan., 1923.)—The variation of the power loss in dielectrics with frequencies varying from 5×10^2 to 10^6 is studied. In a condenser, dielectric absorption is always accompanied by a loss of power which appears as heat in the condenser, and there is a component of e.m.f. in phase with the current. The effect of absorption is therefore equivalent to that of a resistance either in series or in parallel with the dielectric. The author describes a new bridge method for measuring the power loss in a dielectric. The bridge has two resistance ratio arms and two similar variable air condenser arms which are made to act as pure capacities by connecting their insulating supports in parallel with the resistance arms, thus avoiding losses. The condenser to be studied is connected in parallel with one of the bridge condensers set at zero and its equivalent series resistance is determined using, as the source of oscillations, a thermionic valve circuit. The theory of the bridge is given. For frequencies above 3000 a resonance substitution method is used, correction being made for the losses in the standard condenser. Results are given for glass, pyrex, paraffin, ceresin, mica, and Murdoch composition.

For a condenser, C, with a small equivalent series resistance R, the complement ψ of the phase angle is small, $\tan\psi = R\omega C = \sin\psi$ (approx.). The power loss is $EI \sin\psi = E^2R\omega^2C^2$ and the power factor $F = \sin\psi = R\omega C$. Hence the power loss per unit impressed voltage, P, is given by $P = 2\pi fCF$ where f is the frequency and F depends only on the material. It is found that approximately $R = A/f^k$, $P = Bf^n$ and hence $F = 2\pi fRC = D/f^{\frac{k-n}{2}}$ where A, B, D, k, and n are constants. The constants for the substances mentioned are given; for paraffin, mica, and pyrex, D is 0·00174, 0·0132, and 0·0264 while $(k - n)$ is 0·30, 0·23 and 0·215 respectively and $k + n$ is always close to 2, the difference being due to the small change of capacity with frequency. The constant n is the same as in the equation of v. Schweidler for the residual charge current $i = EC_0\beta t^{-n}$ where E is the harmonic impressed e.m.f., β is a constant, C_0 the capacity for infinite frequency, and t the time. This equation is shown to lead to the above equation for power loss and also to $C = C_0(1 + Mf^{n-1})$ where M is a constant. Values of n determined from the variation of capacity with frequency agree closely with those given above. This agreement confirms the theory and indicates the accuracy of the measurements. T. H.

2265. *Thomson's Method for the Measurement of Galvanometer Resistance.* **M. Oyama.** (Inst. El. Eng. of Japan, J. No. 414. pp. 33–41, Jan., 1923.)—The author discusses the sensitiveness of this method and the best conditions. W. R. C.

2266. *Measurement of Peak Voltages with Glow-Tubes.* **A. Palm.** (Zeits. techn. Physik, 4. 6. pp. 233–245, and 4. 7. pp. 258–270, 1923.)—The property of glow-tubes (tubes with two electrodes filled with inert gas at low pressure) of lighting only when a certain minimum pressure is applied across the electrodes is used to measure the peak voltage of an a.c. supply. If resistances R_2 and R_1 are connected in series across the supply whose peak voltage V is required, and if a glow-tube of minimum lighting voltage V_g is connected across the resistance R_1 and R_2 is decreased (or R_1 increased) until the tube just glows, then $V = V_g\left\{\frac{R_2}{R_1} + 1\right\}$ and is known. A telephone receiver connected in series with the glow-tube provides a sensitive indication of when the tube just becomes conducting, and condensers or inductances can be used instead of the resistances R_1, R_2.

The success of the method depends upon the constancy of V_g under all conditions, such as the wave-form and frequency of the supply voltage, the life of the tube, and the temperature, and much of the paper is devoted to an examination of tubes of various electrode constructions and gas pressures at various frequencies up to a million. Measurements are made at low voltages and at high voltages, and the construction of a commercial instrument embodying the method is described. E. M.

2267. *The Design and Construction of Glass Condensers.* **S. Bekku** and **T. Aikawa.** (Inst. El. Eng. of Japan, J. No. 414. pp. 57–65, Jan., 1923.)—The construction of glass condensers by laboratory methods is described, the object being to produce such condensers for use with an artificial, three-phase, power transmission line 400 kilo-

metres long, at an operating voltage of 3000 volts. Ordinary plain window glass 0·2 cm. thick, free from air bubbles is used. This is coated with electrolytic copper (4 mils thick), and the whole is impregnated with paraffin. The total number of condensers so constructed was 1010.
W. R. C.

2268. *Alternating-Current Bridges.* **S. Jimbo.** (Inst. El. Eng. of Japan, J. No. 420. pp. 694–700, July, 1923.)—The author gives a generalised mathematical treatment of this subject. W. R. C.

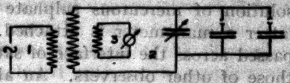
2269. *Sensitive Electroscope.* **T. Shimizu.** (Japanese Journ. Phys. 1. 9–10. pp. 107–111, 1923. In English.)—A variety of the electroscope invented by C. T. R. Wilson, devised to meet as far as possible the following requirements: (1) The torque exerted upon the moving part when the voltage to be measured is applied to the instrument should be large and as nearly constant as possible throughout the range of deflection; (2) mutually attracting parts should be near to each other; (3) the residual restoring couple should be small and vary linearly with the deflection; (4) the zero position of the moving part should be constant; (5) the inertia of the moving part should be small; (6) the electrostatic capacity of the instrument should be small. A sketch shows the electroscope with its attracting plates firmly fixed in fibre blocks connected rigidly to metal pieces, and the way the couple, exerted by the plates upon the fibre, varies when the latter is displaced from the centre is indicated qualitatively by diagrams. The method of adjusting and using the instrument is described. T. C. H.

2270. *Electromotive Force Measurements with a Saturated Potassium Chloride Bridge, or with Concentration Cells with a Liquid Junction.* **G. Scatchard.** (Am. Chem. Soc., J. 45. pp. 1716–1724, July, 1923.)—Results and their interpretations previously published are discussed. Fales and Vosburgh's proof that the saturated KCl bridge eliminates liquid-junction potentials depends upon the assumption that in a solution of HCl the activities of the two ions are equal. It is claimed that Corran and Lewis' proof depends upon incompatible formulæ for the e.m.f. at the two electrodes. Analysis of experimental results indicates that the liquid-junction potential with saturated KCl is not more than 1 millivolt for solutions less than 0·1M, but that it increases rapidly with the concentration for HCl. A. B. C. L.

2271. *Design and Use of Conductance Cells for Non-Aqueous Solutions.* **J. L. R. Morgan** and **O. M. Lammert.** (Am. Chem. Soc., J. 45. pp. 1692–1705, July, 1923.)—Errors inherent in the design and use of conductance cells containing non-platinised electrodes, when employed for non-aqueous solutions, are considered and it is concluded that in order to make accurate conductance measurements of dilute non-aqueous solutions, some comparison solution other than the very dilute aqueous solutions needed should be used, since the latter cannot be kept as free from contamination as the non-aqueous solutions which are to be measured. A solution of KCl diluted with alcohol is suggested as the most convenient comparison solution. The change in resistance with a change in frequency from 500 to 1000 cycles is determined over a wide range of resistances with a number of different cells and types of solutions, the results confirming those of Taylor and Acree in the range covered by them; the difference in resistance for small electrodes does not decrease continuously with increase of resistance, but passes through a minimum between 5000 and 10,000 ohms. There is not, as Taylor and Acree state, a minimum resistance above which a cell may be used with accuracy, but there is an optimum range which may or may not give sufficiently accurate results, according to the size of the electrodes and the accuracy needed. Cells are designed and illustrated which do not change in resistance with a change in frequency and cover the range from 2×10^{-3} to 2×10^{-7} reciprocal ohms. Special attention is given to the cleansing and drying of the cells—errors from this source may amount to 2–3 %, and the method found most suitable is described in detail. A. B. C. L.

2272. *The Calculation of the Skin Effect in Electrical Conductors.* **F. F. P. Bisacre.** (Phil. Mag. 45. pp. 1026–1049, May, 1923.)—The author develops a new method (employing Hankel functions) which he considers preferable to the "ber-bei" method. Two problems are dealt with, *viz.* the hollow cylinder and the concentric cable, and a numerical example of the latter is worked out. G. W. O. H.

2273. *The Wave Meter as a Substitute for Oscillographs for Wave Analysis.* (Elekt. Zeits. 44. pp. 757–758, Aug. 9, 1923.)—It is shown that a non-sinusoidal wave-form can be analysed more easily and accurately by aid of a resonance circuit than by means of an oscillograph, the recorded wave being analysed in the latter case by means of Fourier's series. The method recommended is an adaptation to low frequencies of the method devised for high-frequency circuits by Meissner [Abstract 760 (1920)]. The arrangement is that of the high-frequency wave meter, consisting of a resonance circuit, 2, and an aperiodic indicator circuit, 3, coupled therewith. The wave meter is coupled with the a.c. circuit, 1, under investigation, so loosely that there is no appreciable reaction. If the current i_1 be sinusoidal, the relations under conditions of resonance are: $j\omega L_{12} i_1 = W i_2$; with $W = W_2 + \frac{\omega^2 L_{23}^2}{W_3^2 + \omega^2 L_3^2} W_3$. Also, $i_1 = -i_3 \frac{W}{\omega_2} \cdot \frac{W_3 + j\omega L_3}{L_{12} L_{23}} = i_3 f$. The amplitude of i_1 to be measured is thus directly proportional to that of i_3, *i.e.* proportional to the deflection of the measuring instrument, and also proportional to a factor which varies with ω. If the current in circuit 1 be not sinusoidal, this relation holds for each harmonic with which the wave meter is brought into resonance. Any permanent deflection i_0 derived from the fundamental wave can be taken into account by putting i_1 proportional to $\sqrt{(i_3^2 - i_0^2)}$. It remains only to determine the proportionality factor f. In the expression for this, W represents the total resistance of the wave meter and must be as low as possible in order that sharp tuning may be secured. This may be secured by reducing the mutual inductance L_{23}. In order to obtain satisfactory deflections L_{12} must be increased. This raises the voltage in the resonance circuit and a limit is placed upon the reduction of L_{23} by the voltage permissible on the condenser. W increases with



increase in frequency. In order that the second part of the expression for f may not vary with ω, L_3 must be small, so that the apparent resistance of the indicator circuit may be neglected in comparison with its ohmic resistance. The proportionality factor is then obtained by dividing the value of W by the square of the corresponding frequency. Typical calibration curves are given in the original. The analysis of the wave requires only the multiplication of the maximum deflections from a series of resonance settings by the appropriate factors. R. E. N.

2274. *Impulse Voltages.* **M. Otani.** (Inst. El. Eng. of Japan, J. No. 418. pp. 442–457, May, 1923.)—The form and magnitude of impulse voltages and currents are studied by means of a kathode-ray oscillograph. W. R. C.

2275. *Delineation of Wave-Forms of Radio-Frequency Currents.* **Y. Watanabe.** (Inst. El. Eng. of Japan, J. No. 414. pp. 42–56, Jan., 1923.)—The author studies wave-forms by means of a Braun tube. The deflecting forces are due to the current and to the terminal voltage of an inductance, these forces being at right angles to one another. W. R. C.

2276. *Effects Obtained with an Alternating Current Sent through a Capillary Electrometer.* **R. D. Kleeman** and **D. T. Simonds.** (Phys. Rev. 21. pp. 38–45, Jan., 1923.)—A special form of capillary electrometer is used in which a horizontal capillary, whose bore increases gradually from the middle towards both ends, connects a reservoir of saturated solution of mercurous sulphate with a reservoir of mercury. To the latter a manometer is attached. The results when a direct current is passed across the interface of saturated solution and mercury agree with those of other observers. An alternating current is found to move the thread of mercury in the same direction as it is moved by a direct current from solution to mercury, *i.e.* it increases the interfacial surface tension. This is not due to a direct-current component produced by a rectifying action of the electrometer, for this component is found to flow in the opposite direction, and when it is eliminated by inserting a condenser in the circuit still larger deflections are obtained. The pressures required to keep the mercury at the middle point of the capillary increase more or less linearly with the voltage up to 10·5 cm. of Hg at 1·15 volts and then remain constant to 1·4 volts. The same results are obtained with alternating-current frequencies from 60 to 200 cycles. The transition layer theory which one of the authors has given in explanation of the e.m.f. of a voltaic cell [Abstract 235 (1923)] is applied to the results and provides an explanation at least better than the Helmholtz theory. T. H.

ALTERNATING CURRENTS AND MAGNETISM.

2277. *Induction in a Ring Provided with Two Windings.* **J. Sahulka.** (Elek. u. Maschinenbau, 41. pp. 382–384, July 1, 1923.)—The author describes an experiment in which a wire, earthed at one end, is led through the centre of a ring transformer to a quadrant electrometer. When an alternating current is sent through the primary an alternating voltage is produced in the above wire, and by a suitable device is made to deflect the electrometer, although too small to do so under ordinary conditions. This e.m.f. cannot be caused by lines of force cutting the wire, and the author apparently does not consider that it can be explained by the variation of N through the circuit earth, wire, capacity of condenser and attached capacity earth. The author assumes that the lines of force never come outside the iron core, and apparently ascribes the induction to ether particles, regarded as identical with negative electrons, which flow in and out from the conducting surfaces. H. N. A.

2278. *Magnetic Field of a Helix.* **H. Lamb.** (Cambridge Phil. Soc., Proc. 21. pp. 477–481, June 15, 1923.)—A mathematical analysis based on the assumption that, for example, the field in the interior of a long solenoid is sensibly uniform except near the windings. The form of the results lends itself, if need be, to numerical computation by the methods of the theory of Bessel functions. A. B. C. L.

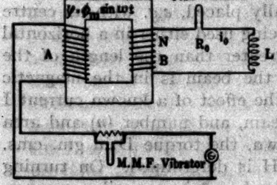
2279. *The Bohr and Weiss Magnetons.* **W. Gerlach.** (Phys. Zeits. 24. pp. 275–277, July 1, 1923.)—A contradiction still exists between the magnetic consequences of the quantum theory and the results of a large number of observers on the magnet moments of atomic ions and gas molecules. Since the direct measurement of the magnetic moment of the normal silver atom by Gerlach and Stern [see Abstract 2055 (1922)] gave a value in agreement with the Bohr magneton, it appears more certain that the difference in the results is to be traced to the mode of evaluating the Weiss magneton. Pauli has pointed out that for the calculation of the magnetic moment the spatial quantelation of the atom magnet in the external magnetic field must be taken into account, and application of this method is now shown to explain the discrepancy. Cabrera's table of measurements is included with much supplementary data. H. H. Ho.

2280. *Balance for Measuring the Magnetic Elements.* **J. Sahulka.** (Elek. u. Maschinenbau, 41. p. 262, April 29, 1923.)—An iron-free balance is made with hard copper knife edges, and carries either one or two coils. In the former case, the coil is symmetrically placed, *e.g.* with its centre above the beam axis, and it is capable of being used either in a horizontal or vertical position, its diameter being greater than the length of the beam. When the coil is horizontal and the beam is in the magnetic meridian, the weight required to balance the effect of a known current I in the coil is found. The length of the beam, and number (n) and area (A) of the windings of the coil being known, the torque D in gm. cms. is given by $D = nAHI/10g$, from which H is determined. On turning the coil into a vertical position, V may be found in a similar manner, and hence the angle of dip is derived. G. E. A.

2281. *Magnetic Material for High-Frequency Fields.* **R. Gans.** (Phys. Zeits. 24. pp. 232–235, June 1, 1923.)—The author derives expressions for the magnetic constants of a core consisting of iron powder embedded in paraffin and subjected to the action of a high-frequency magnetic field. Making certain simplifying assumptions, *viz.* that the particles of iron are all spherical and of the same radius, and are distributed at random at distances which are great compared with their radius, it is shown that the high-frequency permeability of such a core depends only upon the space occupied by the particles, and that the magnetic conductivity depends in addition upon the electric conductivity, the square of the diameter of the particles, and the square of the frequency of the magnetic field. J. S. G. T.

2282. *Magnetic Properties of "Permalloy."* **H. D. Arnold and G. W. Elmen.** (Electrician, 90. pp. 672–674, June 22, 1923. Frank. Inst., J. 195. pp. 621–623, May, 1923.)—Permalloy is the name given to the range of nickel-iron alloys which contain above 30 % nickel. The 78·5 % Ni alloy has the highest initial permeability. The alloy is made in the form of tape 3·2 mm. wide and 0·15 mm. thick. This was tested magnetically in a ring permeameter of special design. To develop the magnetic properties of the alloy, which is very sensitive to heat treatment, the specimen is heated at about 900° C. for an hour and allowed to cool slowly; it is then reheated to 600° C. and placed on a copper plate which is at room temperature. The magnetic properties of the 78·5 % alloy are exhibited by means of curves, corresponding curves being given for armco iron. The initial permeability at room temperature is about 13,000, or more than thirty times that of the best soft iron. This remarkable fact is brought out otherwise by stating that the alloy has a saturation intensity comparable with that of iron and approaches saturation in the earth's magnetic field. The area of the permalloy hysteresis loop is only a sixteenth that of the loop for soft iron, and the maximum permeability is 87,000 for B about 5000. Heat-treated permalloy is sensitive to mechanical strain, and the permeability can, within limits, be adjusted to any required value by varying the mechanical strain. The conductivity of the alloy is reduced about 2 % both by strain and by magnetisation. [See also Abstract 967 (1923).] G. E. A.

2283. *Incremental Permeability.* (Am. I.E.E., J. 42. pp. 849–851, Aug., 1923.)—This is a discussion on the paper referred to in Abstract 764 (1923). **E. L. Bowles** states that the reactance of an iron circuit depends not only upon the phenomenon of hysteresis but also upon eddy-current loss. There is also the question of the inductance of a circuit containing variable coefficients. An oscillograph has been developed consisting of two vibrators facing each other and at right angles. A beam of light striking one of the mirrors is reflected to the other and then reflected once more. Thus a compounding of the motions of the two mirrors will produce the well-known Lissajous figures in the case where the two motions are harmonic. If the deflection of one of the vibrators is proportional to the magnetising force, and the deflection of the other is proportional to the flux, hysteresis loops can be traced visually and directly photographed. The oscillograph is described and the problem discussed mathematically. The figure shows a circuit with the vibrators inserted. T. C. H.



2284. *Magnetism of Carbon Steels Containing Manganese.* **H. Pécheux.** (Comptes Rendus, 176. pp. 1387–1389, May 14, 1923.)—Three carbon steels which contained small amounts of manganese are tested after annealing and after quenching by a method similar to that used previously [see Abstract 1986 (1923)]. The usual effects ascribed to carbon are noted; the effect of manganese in quenched steel is opposite to that of carbon. The values are given for the composition of the steels, the Steinmetz constant and the Brinell hardness members. The hardness is affected by the carbon but not by the manganese. **Errata** (*ibid.* p. 1580, May 28, 1923). G. E. A.

2285. *Complex Permeability of Iron.* **H. Nukiyama** and **Y. Shoji.** (Inst. El. Eng. of Japan, J. No. 419. pp. 546–565, June, 1923.)—The author considers the measurement of the "complex permeability" of iron which is defined as the ratio of the complex effective value of the harmonics of alternating induction to the magnetic force. W. R. C.

2286. *Characteristics of Magnetically Active Iron.* **A. Turner.** (Phys. Rev. 21. pp. 74–83, Jan., 1923.)—The author gives a short summary of previous work on the effects of a constant magnetising force upon the susceptibility due to an alternating magnetising force in iron. When a second alternating magnetising force is substituted for the constant force the effect is widely different. The permeability and hysteresis characteristics of annealed bessemer steel are studied for superposed alternating fields, one field having maximum intensity 0·25 to 4·5 gauss and frequency 30 to 103 cycles, the other 0·01 gauss and frequency 5000 to 50,000 cycles. The specimen is in the form of a laminated steel core round which are wound coils continually in circuit with the low-frequency current. Other coils are wound on the same core and form one arm of an alternating-current bridge traversed by the high-frequency current from a vacuum tube oscillator. An interrupter in the high-frequency supply circuit runs in synchronism with the low-frequency alternating current, allowing connection with the bridge to be made at a known phase of the low-frequency current. The effective inductance and resistance of the h.f. coils are measured. The permeability is proportional to the effective inductance and the hysteresis loss is obtained by subtracting from the total energy loss, deduced from the effective resistance, the energy losses due to copper resistance and the calculated Foucault current resistance. Curves are given showing the variation of permeability and hysteresis loss with the phase of the low-frequency field, for various intensities of the field up to 4·5 gauss. They show maxima and minima for intensities above 0·25 gauss. On increasing the frequency of the high-frequency field the maximum permeability decreases while the maximum hysteresis loss increases, but if the frequency of the low-frequency field be increased, the maximum values of both the permeability and hysteresis loss increase. T. H.

2287. *Evolution of the Molecule Chromium Hydroxide in Water.* **Suzanne Veil.** (Comptes Rendus, 176. pp. 1304–1305, May 7, 1923.)—An outline is given of a series of observations on the magnetic changes in the molecule of chromium hydroxide in water, by a method similar to that previously employed in the case of the molecule of ferric hydroxide [see Abstract 1241 (1923)]. The observations indicate that the molecule of chromium hydroxide is very variable in aqueous media. The magnetic variations, in the inverse sense to those of ferric hydroxide, are besides much less marked. It is of interest to compare these results with those obtained with crystalline substances, in which case the magnetic properties have been found to be rigorously constant by a large number of observers. A. B. W.

2288. *Paramagnetism of Aqueous Solutions of Cobalt Sulphate.* **Chatillon.** (Comptes Rendus, 176. pp. 1608–1611, June 4, 1923.)—Cabrera, Moles, and Marquina found that the coefficient of magnetisation was variable with the concentration for cobalt sulphate, nitrate, and chloride; the curve representing the atomic moments has two branches, which indicate for infinite dilutions, 24 and 24 magnetons per atom respectively. On the other hand, Trümpler, using solutions prepared without heating, found a constant coefficient, with an apparent mean moment equal to 24·5 magnetons per atom. The present observations confirm both these results, and show that the atomic moment of the solutions prepared by heating remains constant for a considerable time. Cold preparation gave solutions the apparent atomic moment of which was independent of the concentration, and, within certain limits of temperature of observation, was equal to 24·5 magnetons. Preparation by boiling gave solutions which point to the existence of carriers with 24 magnetons, and others with 25. Solutions, the atomic moment of which is not a whole number (24·5), can then be regarded as the result of association of the two kinds of carriers with whole numbers of magnetons; this association is broken up by a high temperature, and replaced by an equilibrium, which is a function of the concentration, and which does not vary with the time. H. N. A.

2289. *Terrestrial Magnetic Disturbances and Solar Activity.* **G. Angenheister.** (Terrest. Magn. 28. pp. 45–47, March–June, 1923. In German.)—The tendency for great magnetic storms to occur at intervals which are whole multiples of about 30 days has led the author to advance a theory that the responsible solar disturbances are situated in deep-seated layers of the sun, where they may persist for a spell of years and rotate in intervals of 30 days [see Abstract 90 (1923)]. The present paper contains a further discussion of the theory to reconcile it with the fact that even the great magnetic storms often occur 27, 54, 81 . . . days after disturbed days, thus apparently forming part of the short-lived 27-day cycles associated with disturbances in the higher solar strata.

M. A. G.

2290. *Magnetic Measurements in Angola and Rhodesia by the Rohan-Chabot Mission.* **de Rohan-Chabot.** (Comptes Rendus, 177. pp. 458–460, Aug. 20, 1923.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2291. *Improvements in the Mode of Measurement of Osmotic Pressure.* **A. Grollman** and **J. C. W. Frazer.** (Am. Chem. Soc., J. 45. pp. 1710–1716, July, 1923.)—Experiments are described in which the cells to be employed for osmotic pressure determination are first "filled" with various silicates (principally that of Mg) before the precipitation of the colloidal copper ferrocyanide membrane. Such cells do not require long seasoning, and whilst allowing a minimal leakage afford rapid attainment of equilibrium. A description is given of an interferometer cell which is capable of acting as an accurate and rapid pressure gauge. A. B. C. L.

2292. *The Nature of Chemical Luminescence.* **H. Kautsky** and **H. Zocher.** (Zeits. Elektrochem. 29. pp. 308–312, July 1, 1923. Paper read before the Deut. Bunsen. Gesell, Hanover, May, 1923.)—Referring to the researches of Haber and Zisch on gas reactions [Abstract 1994 (1922)], the authors, from their own experiments on "chemiluminescence," conclude that generally (also in cases of liquids and solids) in chemical reactions the chemical energy may be concentrated in certain complexes which either emit radiations directly or transfer their energy to other molecules while passing into more stable forms. The occurrence of "chemiluminescence" depends upon the presence of some material which is capable of radiating when receiving the necessary chemical energy; such material may be one of the original reacting bodies, or some intermediate or final product, or some foreign substance. They find such materials by decomposing calcium silicide $CaSi_2$ with hydrochloric acid. The reaction [Zeits. f. Physik 9. p. 267 (1922)] yields, under evolution of hydrogen, unstable intermediate products, oxydisilin $Si_2H . OH$, silical hydroxide $Si_2OH . OH$, leukon (composition uncertain), strongly reducing substances, very sensitive to light, and finally silicic acid; the external structure of the silicide is retained in the products. The silical is dark red and yields with acids yellow or red compounds; it is itself fluorescent and therefore less suitable for these experiments than the colourless oxydisilin and the silicooxalic acid. Adsorbed by these latter two solid compounds of high surface development, aqueous solutions of fluorescent colouring matters like rhodamine show "chemiluminescence" in the presence of oxidising agents (hydrogen peroxide). It is, however, striking that the strongly fluorescent fluorescein is much less "chemiluminescent" than silical, possibly because in liquids the local centres of reaction and emission may be separated from one another by molecules of the solvent. In the organic magnesium compounds (Grignard) chemiluminescence and fluorescence do not, so far as present experiments go, appear to be in accord. H. B.

2293. *Luminous Pulsations in the Glow of Phosphorus.* **H. P. Waran.** (Phil. Mag. 45. pp. 1132–1139, June, 1923.)—An interesting description is given of certain observations of the pulsations in luminous glow produced on admitting dry oxygen into an evacuated vessel containing phosphorus. An explanation offered is that below certain pressures (too small to measure) phosphorus will not combine with oxygen and that the explosive or luminous combination of phosphorus vapour and oxygen is governed by the fact that their partial pressure in the mixed atmosphere must bear a certain minimum ratio before combustion can spontaneously originate or be maintained in the mixture. A. B. W.

2294. *A Stream-Line Filter.* **H. S. Hele-Shaw.** (Roy. Soc., Proc. 103. pp. 556–561, July 2, 1923.)—In applying the author's stream-line method to very thin films (1/10,000th of an inch and less) the stream-lines were invisible, and it was found that the liquid which passed lost its colour. This suggested the use of thin films between sheets of impermeable material as a means of pressure filtration. Ultimately paper, with a matted surface or faintly embossed with a stream-line pattern, was found to be satisfactory. It was cut with holes as indicated in the Figs. 1 and 2, and hundreds or thousands of sheets pressed together between plates, the holes thus forming tubes. The fluid is introduced into the larger tubes, and the filtrate issues from the smaller ones. Further details of suitable apparatus are given. By this method of filtration, the filtrates of solutions of aniline dyes are colourless, and heavy oil is removed from paraffin. W. G. B.

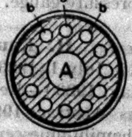


FIG. 1.

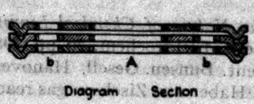


FIG. 2.

2295. *Electric-Furnace Purification of Zirkite.* **J. G. Thompson.** (Am. Electrochem. Soc., Trans. 40. pp. 445–454; Disc., 454–455, 1921.)—This paper is similar to that referred to in Abstract 767 (1923). W. R. C.

2296. *Atmospheric Pollution.* **Eighth Report of the Committee for the Investigation of Atmospheric Pollution issued by the Meteorological Office.** (Meteorolog. Office, Air Ministry, [42 pp.] 1923.)

2297. *Gaseous Combustion at High Pressures.* **W. A. Bone.** (Nature, 112. pp. 364–370, Sept. 8, 1923. Discourse delivered at the Royal Inst., May, 1923.)—General considerations based upon the author's recent researches [Abstract 2013 (1923)]. There is no direct relation between the rate at which the potential energy of an explosive mixture is transferred to its products as sensible heat (pressure) and the magnitude of the chemical affinity between its combining constituents; in other words, the avidity with which a gas seizes upon oxygen in flame combustion is not necessarily the main factor governing the rate of transference of energy. Thus, in flames the affinity of methane for oxygen is more than twenty times greater than that of hydrogen; yet the time required for the attainment of the maximum pressure is much longer in methane-air mixtures than in hydrogen-air mixtures. As regards carbon monoxide, which burns in air more slowly and with a more highly radiating flame than does hydrogen, the author suggests that CO and O_2 molecules are mutually inert in flames; the O_2 must be resolved into either oxygen atoms or activated steam, the presence of hydrogen or steam being necessary. In that case the heated oxygen molecule can, by having its "residual affinities" stimulated, at the moment of combustion, form intensely vibrating complexes H_4O_2 which instantly break down, partly into two molecules of activated steam and partly into two O atoms and two H_2 molecules. H. B.

2298. *The Rotatory Power of Chemical Compounds in Relation to their Molecular Configuration and the Theory of the so-called Asymmetric Atom.* **F. M. Jaeger.** (Soc. Chim. de France, Bull. 33. pp. 853-889, July, 1923.)—The foundation of stereo-chemistry may be regarded as resting on the theory of asymmetric atoms as put forward by van't Hoff and Lebel to account for the enantiomorphous relationship accompanied by optical rotatory power. In spite of the importance of its developments, the theory has introduced serious obstacles to a clearer understanding of the fundamental causes which determine optical activity on account of the exclusive consideration which has been given to the chemical contrasts existing between different substituents which are grouped around the central polyvalent atom in question and because the theory requires a total molecular asymmetry which is determined by the particular chemical character of the molecule.

The earlier view of Pasteur that the enantiomorphous relation is determined by the configuration in space of the entire molecule is held to be more in accordance with the present knowledge of this subject. It is considered preferable to make use of the principle of symmetry as a more fundamental basis of optical activity while the asymmetric atom merely forms a special case amongst others.

Many instances have been encountered where a racemic condition has been demonstrated with molecules which, judged by the chemical standard, are apparently symmetrical. Further, a number of instances are cited of molecules which contain an unsymmetrical carbon atom but which are seen by a three-dimensional model to be incapable of resolution into optical antipodes. In these cases the entire molecule possesses a centre of symmetry and no racemic forms are derivable. The fundamental cause of optical activity is to be regarded as residing in the spatial distribution of optically active electrons in the exterior or secondary sphere of the atoms which constitute the molecules. The conception of "centre of optical activity" in the molecule is introduced to describe a polyvalent atom carrying a system of electrons which resonate according to a dissymmetric configuration irrespective of the diversity of the attached radicles. The Werner compounds derived from the trivalent elements Cr, Co, Rh, Ir, and Fe and the tetravalent element Pt provide noteworthy examples where the substituted groups are identical, but have a spatial arrangement which is dissymmetrical, giving two enantiomorphous configurations. The investigation which has been made of compounds of this type after resolution into their optical isomers includes a study of their crystalline forms and the rotatory dispersion of their solutions. Very characteristic differences are exhibited in the curves expressing the relation between optical rotation and wave-length. In many cases a change in wave-length causes a change in the direction of rotation. The effect of circular dichroism observed by Cotton becomes apparent. In accordance with Drude's theory the rotatory dispersion is to be related to the resonance of the electrons rather than to the material composition of the substituted groups. It is also in accordance with the deductions of Born and Stark that optical activity generally is based primarily on the configuration in space of particular groups of electrons, the characteristic frequencies of which account for the anamalous dispersion observed. The dissymmetric distribution of active electrons may be in virtue of their position in space or on account of their intensity or the particular manner of oscillation. The theory is in general parallel to the older chemical view of a dissymmetric distribution of the atoms in the molecules. J. N. P.

2299. *Calculation of Molecular Weight from Critical Data.* **W. Herz.** (Zeits. Electrochem. 29. pp. 394–395, Aug. 1, 1923.)—From considerations of Mathias and of S. Young, D. Berthelot deduced in 1909 the formula: molecular weight $M = 11{\cdot}4dT_k/p_k(2 - T/T_k)$, where d is the density at temperature T, p the pressure, and k stands for critical. The author finds that for non-associated liquids (methyl acetate, chlorobenzene, heptane, tin tetrachloride), the formula yields too high values for M when d is determined at low temperature (near 273° K.) and too low M when d is determined at high temperature, the intermediate values being correct. For associated liquids (alcohols, acetic acid) the formula gives much too high values, except at high temperatures. H. B.

2300. *The Origins of the Conception of Isotopes.* **F. Soddy.** (Roy. Inst., Proc. Advance Proof received July, 1923. Nature, 112. pp. 208–213, Aug. 11, 1923.)—Contains a historical sketch of the discovery of the radio-active elements and their relations to one another and to previously known elements. H. N. A.

2301. *Separation of Isotopes of Zinc.* **A. C. Egerton** and **W. B. Lee.** (Roy. Soc., Proc. 103. pp. 499–515, June 1, 1923.)—Two sets of high vacuum distillations of pure zinc are described, conditions being adjusted to obtain a slightly different concentration of the isotopes in the final residue of the final distillate. The densities of the samples obtained are determined according to the method described in a previous paper [see Abstract 2051 (1923)]. In the first set of distillations the distillate is of the same density as the original zinc, the residue being slightly denser. In the second set the density of the residue increases by about 1/3700 and that of the distillate decreases by about 1/3600. Flaws, allotropes, impurities, and variation of physical conditions are shown to be improbable, and the result lies outside the experimental error. The amount of the separation agrees with Dempster's observations of isotopes of weights extending over 6 units (*viz.* 64–70), but is not as great as might be found for equal parts of 64 and of atoms of weights 66, 68, and 70. A. B. C. L.

2302. *Deductions from the International Table of Isotopes,* 1923. **H. Collins.** (Chem. News, 127. pp. 52–55, July 27, 1923.)—The author deduces the facts that, as a general rule, the masses of the isotopes are even, when the atomic numbers are even, and odd when the atomic numbers are odd; that for the dominant isotopes there are only two exceptions to this rule out of 26 cases; that the maximum valency is generally odd when the atomic number is, and conversely; that the atomic number gives the number of 3's and 1's into which the mass of the dominant isotope can be split up, always commencing with a 3 and taking the 3's and 1's alternately (Mg, $N = 12$, at. wt. of dominant isotope $24 = 3 + 1 + 3 + 1 + 3 + 1 + 3 + 1 + 3 + 1 + 3 + 1$; this holds up to Ca, $N = 20$); that up to Ca if the mass of the dominant isotope is an even number $N =$ at. wt./2, and if the mass is odd $N =$ (at. wt. $-$ 1)/2 must depend upon some fundamental and uniform connection between the atomic numbers, the isotope masses, and the valencies. The author traced the connection between Cl (35) heptad, P (31) pentad, Al (27) triad, Na (23) monad; between S (32) hexad, Si (28) tetrad, Mg (24) dyad [this series can be continued through Ne, O, and C]; and between B (11) and Li (7) in 1906, when he stated "The non-metallic nature of an element is always due to a pair or pairs of electropositive forces, each pair emanating from a portion of the element of which the mass is 4, taking the mass of an atom of hydrogen as unity." H. N. A.

2303. *Heat-Resisting Glasses.* **W. E. S. Turner.** (Roy. Soc. Arts, J. 71. pp. 401–408; Disc., 408–412, April 27, 1923.)—The development of the manufacture of heat-resisting glasses is reviewed historically. Earlier attempts were designed to improve the mechanical strength by various hardening processes, the later and more successful developments being based on the control of the coefficient of expansion. Details are given of the investigations of Schott and Winkelmann of the effects of various basic and acidic oxides on glasses into the composition of which they enter, together with a list of so-called "expansion factors." B_2O_3 and SiO_2 in particular are associated with small expansion, the former presenting the fortunate combination of low expansion and ready fusibility. It is found, however, that B_2O_3 can only be advantageously employed over a certain range, *viz.* in the neighbourhood of 11 %–12 % from the point of view of durability (against action of water and acids) and of 20 % from the point of view of minimum coefficient of expansion. The effects of variation of B_2O_3 content are illustrated in graphs. In the *discussion,* **H. Jackson** refers to the prevention of devitrification in repeated blowing afforded by titania up to 5 %. In further discussions the subject of the fusibility of various metals into glass is touched upon. A. B. C. L.

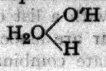
2304. *Di-Phasic Nature of Glass.* **L. N. G. Filon** and **F. C. Harris.** (Roy. Soc., Proc. 103. pp. 561–571, July 2, 1923.)—In the course of investigations on the effect of temperature on the stress-optical coefficient of glass, the stressed specimen was once maintained at about 400° C. for 42 hours, and then slowly cooled. Considerable residual longitudinal stress difference was found. As the transverse stress is usually small, the stress across a section would appear to be non-equilibrating. Either the transverse stress is not small, or there is some stress not revealed optically (provisionally termed "crypto-stress"). From optical determinations, by a new method here published, involving numerical integration along the lines of principal stress, the two stresses are determined, and the longitudinal stress so determined does *not* have a zero resultant when taken over the section—a result in contradiction of the laws of statics. Hence it is concluded that glass consists of two phases, having different stress-optical coefficients. A possible explanation is that one of the phases is plastic at the high temperature, so that on cooling, both phases are in a state of stress. Further work is in progress, but the evidence of the di-phasic nature of glass is thought to justify early publication. W. G. B.

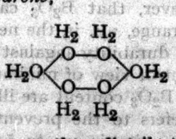
2305. *Composition, Purification, and certain Constants of Ammonia.* **E. C. McKelvy** and **C. S. Taylor.** (Bureau of Standards, Sci. Papers No. 465. pp. 655–693, 1923.)—The paper describes chemical tests made on several standard brands of commerical ammonia. The results of these analyses indicate that most commercial ammonias contain less than 0·1 % of impurities. Five methods of the preparation of pure samples of ammonia are described and a sample was prepared which contained, as far as any known test indicated, no organic impurities, less than 1 part in 1,000,000 by volume of non-condensing gases, and less than 0·003 % by weight of water.

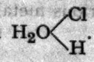
The following physical properties of pure ammonia were determined :

The *density* of the solid, 0·817 g./cm.^{3} at − 79° C. and 0·836 g./cm.^{3} at − 185° C.

The *freezing-point*, − 77·70° C., and the *vapour pressure* at that temperature, 45·2 mm. of mercury. E. G.

2306. *Origin of Osmotic Effects. Part IV. Hydronodynamic Change in Aqueous Solutions.* **H. E. Armstrong.** (Roy. Soc., Proc. 103. pp. 610–618, July 2, 1923.)—The view is put forward that the vapour pressure of water is a measure of the proportion of *hydrone*, H_2O, which it contains as compared with *hydronol*  $H_2O<\substack{OH\\H}$ and the cyclic polyhydrones such as *hexahydrone*,



Electrolysis is dependent on the distribution of one molecule on another as in the compound  $H_2O<\substack{Cl\\H}$. Osmotic pressure is due to the fact that whilst each molecule of the solute fixes one molecule of hydrone, thus lowering the vapour pressure, this complex does not lose its power to attract hydrone. Potential electrolytes give rise to two of these attractive complexes. For details of the theory and the arguments in support of it, the original paper should be consulted. T. M. L.

2307. *The Stratified Subsidence of Fine Particles.* **C. E. Mendenhall** and **M. Mason.** (Nat. Acad. Sci., Proc. 9. pp. 199–202, June, 1923.)—When fine particles are allowed to subside in a liquid it has been observed that, under some circumstances, the mixture divides into a series of layers, each of more or less uniform opacity ; but that the opacity of successive layers increases by sudden jumps from the top downwards. The authors found that the phenomenon does not take place when the tubes containing the mixture are kept in a dark room ; and conclude that it is due to a lateral temperature gradient across the liquid. A number of experiments were made which confirmed this; and the existence of a complicated system of convection currents was demonstrated in a stratified tube by carefully injecting small amounts of water coloured with fluorescein at suitable points. The phenomenon depends on the increase in density downwards through the mixture, due to the suspended particles. H. N. A.

2308. *Theory of the Settling of Fine Particles.* **M. Mason and C. E. Mendenhall.** (Nat. Acad. Sci., Proc. 9. pp. 202–207, June, 1923.)—The authors deduce a mathematical theory for the position of the layers described in the preceding abstract; and give a curve showing the relation to be expected between density of particles and depth. The theory was confirmed in part by experiments. H. N. A.

2309. *Electrical Properties of Gels.* **F. Michaud.** (Comptes Rendus, 177. pp. 30–32, July 2, 1923.)—It was found in an earlier investigation [Abstract 1698 (1923)] that on submitting a gel to an electric current a deformation occurs which is related to electrical endosmose. In the present paper it is shown that, conversely, a pressure gradient in a gel is the seat of an e.m.f., the direction of the electric field being opposite to that of the pressure gradient. The phenomenon is again attributed to the spongy structure of gels and the existence of an electrical double layer on the partitions of the interstices. Compression at one point displaces the liquid which entrains its positive charge, leaving behind the corresponding negative charge. With gel fibres suspended in liquids a tension produces a current which passes from the liquid to the fibre, and a release produces an inverse current. The term "mechano-electrical coefficient" is introduced to denote the ratio between the pressure gradient and the potential gradient. With gelose a difference of pressure of 10^5 dynes ($\frac{1}{10}$ atm.) gives a p.d. of the order of 1 millivolt. With animal and vegetable membranes, in addition to the electrical polarisation produced by the semipermeability of the membrane, it would appear that in the case of spongy tissues such as protoplasm, pressure gradients produced in vital processes lead to an electric polarisation and a consequent selective absorption of the ions of the mineral salts. This phenomenon is considered to play an important part biologically in cellular nutrition and physiologically in nerve processes. J. N. P.

2310. *The Periodic Opacity of certain Colloids in Progressively Increasing Concentrations of Electrolytes.* **J. Holker.** (Roy. Soc., Proc. 102. pp. 710–734, March 1, 1923.)—It is found that when electrolytes of progressively increasing concentration are added to suspensions of certain colloids the opacity of the liquid increases and decreases in a marked periodic manner. The colloid studied more particularly is human serum after "inactivating" by heating at 56° C., and other colloids investigated are various animal sera, gelatin, gum acacia, agar, gum mastic, and dialysed hemoglobin. The electrolyte used is principally sodium chloride, while potassium chloride, hydrochloric acid, and sodium hydroxide are also tried. Measurements with light of different wave-lengths are made of the amplitude (A) of the oscillation periods of the curves of opacity plotted against concentration of salt, and their length (L), and the ratio A/L is termed the "characterising ratio." From the nature of the curves it is inferred that the periodicity in the opacity is not due to an optical interference of the light scattered by particles uniformly changing in size, but is rather due to an oscillatory change in the physical condition of the particles. On varying the concentration of serum as well as salt, it is found that the characterising ratio is a simple linear function of the concentration of serum except at high dilutions when the ratio diminishes very rapidly. The use of potassium chloride gives results similar to those with sodium chloride, the characterising ratio being 20·0 as compared with 16·5 for sodium chloride, the values being very close to the ratios of equivalent conductivities of these salts at infinite dilutions at 18° C. With alkali and more particularly with acid the action is extremely great compared with that of neutral salts, and maxima are given of a very high degree of turbidity, while the oscillatory character of the curve is completely lost. Other colloids examined show a similar relation to that obtained with human serum but with lower characterising ratios. The periodic opacity phenomena is observed when increasing concentrations of calcium chloride are added to buffer solution of acid and alkaline sodium phosphate in the absence of any colloid.

The phenomena are considered to be due to a periodic variation in the physical condition of the particles of the colloid scattering the incident light, from which it follows that a periodic reaction occurs between the colloid and the added electrolyte. The determining factors are considered to bear a close analogy to those operating in the periodic law of the elements, the periodicity in both cases being associated with a progressive increase in the number of protons and electrons. As with the electronic structure of atoms, the mechanism with colloids must depend upon the nature of, and the spacing of, the adsorbed atoms forming the surface layer of the colloid and the periodic variation in the opacity of colloids means that the total surface area of the colloid scattering light varies in a periodic manner. A tendency is exhibited for the colloidal particles to revert to more stable forms by giving up or taking up ions or by sharing their outside ions with particles with which they combine. In analogy to the inert elements or stable atoms consisting of those in which the surface layer has its optimum quota of electrons, the stable forms of the crystallo-colloidal complex are those corresponding to the minima in the curves at which points the surface layer of the colloid has its optimum quota of ions. J. N. P.

2311. *Development and Aims of Metallurgical Investigation.* **F. Sauerwald.** (Zeits. f. Metallkunde, 15. pp. 184–190, June, 1923.)—This paper forms a survey of the present methods and routine of metallurgical investigations. It is pointed out that the most important questions for the metallurgist are the change in properties of the metals with change of conditions, the influence of temperature, changes of form, and how these properties are altered by alloying one metal with others. These points must be dealt with in every research. The older investigations were made on thermodynamic and allied properties, but the new will have to take account of the theoretical structure and also of the static and kinetic conditions. F. J. B.

2312. *Equilibrium Diagram of Copper-Tin Alloys.* **O. Bauer** and **O. Vollenbruck.** (Mitt. aus. der Materialprüfungsamt, Berlin. No. 5. pp. 181–215, 1922. Zeits. f. Metallkunde, 15. pp. 119–125, May, and pp. 191–196, July, 1923. Extract.)—The authors review previous work on Cu-Sn alloys and emphasise the necessity of extremely slow cooling. They find that the limit of the α field is at 13·9 %, and is independent of temperature below the solidus. They confirm Hoyt's line at 590° C. and Giolitti and Tavanti's suggestion that Cu_3Sn has two modifications, the higher temperature one melting at a constant temperature. They also indicate the existence of the compound Cu_6Sn_5. J. L. H.

2313. *Water-Gas Reactions.* **R. T. Haslam, F. L. Hitchcock,** and **E. W. Rudow.** (Indust. and Eng. Chem. 15. pp. 115–121, Feb., 1923.) —The results of a study of the formation of water-gas at various temperatures between 650° and 1200°, and using steam at different pressures and carbon of two different kinds, leads to the conclusion that the essential reactions are: (1) $C + H_2O = CO + H_2$, (2) $C + 2H_2O = CO_2 + 2H_2$, and (3) $C + CO_2 = 2CO$. These reactions, taking place at the surface of the carbon, are all unimolecular, and a possible explanation of the mechanism of the unimolecular formation of CO_2 is given. Below 900°, the rate of formation of CO_2 is: $(CO_2) = 0{\cdot}5[(H_2O) - (H_2O)^2]$, and above 900° $(CO_2) = 0{\cdot}47[(H_2O) - (H_2O)^{1{\cdot}85}]$. If the velocity of reaction (2) is taken as unity, reaction (1) is practically non-existent below 900° and the velocity of reaction (3) is 2·0; above 900° the velocity constants for reactions (1) and (3) are 1·0 and 2·18 respectively.

The controlling factor in the value of the ratio $CO : CO_2$ is the influence of the undecomposed steam rather than the temperatures at which the reactions take place. Increase in the pressure at which a water-gas generator is worked serves the same purpose as either an increase in the time of contact or in the depth of fuel bed, or a rise in temperature. A threefold increase in pressure almost trebles the output of water-gas from a given plant without altering the composition of the fixed gases. T. H. P.

2314. *The Velocity Constant of a Unimolecular Reaction.* **J. Rice.** (Phil. Mag. 46. pp. 312–320, Aug., 1923.)—The formula $K = s \exp. (-\epsilon/KT)$ for the velocity constant, seems to agree with experiment, at any rate in the case of gaseous reactions. Here s and ϵ are constants for a given compound dissociating into two components, and k and T have their usual meaning. The quantity ϵ is an amount of energy (the "critical increment"), and s must be a frequency. It is plausible, adopting the quantum theory, to write $\epsilon = h\nu$, and to regard ν as the frequency of some oscillatory process within the molecule, which leads to a rupture of the molecule when the amplitude has so increased that the energy is equal to one quantum for this frequency.

Dushman [Abstract 1869 (1921)] has equated s to ν on empirical grounds, obtaining the equation $K = \nu \exp. (-h\nu/kT)$. The present author shows that an equation closely approximating to Dushman's can be obtained by a "quantisation" of an expression obtained by him some years ago. He assumes that a molecule may be represented by a simple mechanical model, in which two bodies are bound by a quasi-electric force, their distance apart being q. The mutual potential energy, $\phi(q)$ of the two components, increases with q until $q = c$. Beyond this critical distance, c, the p.e. either decreases or remains constant. Considering a system made up of such molecules an expression for k is obtained, and this expression, modified in any one of several ways suggested by quantum considerations, leads to formulæ similar to the more or less empirical one employed by Dushman. One suggestion is to assign to the molecular model the properties of a harmonic oscillator, the result being $K = 2\nu \exp.(-h\nu/kT)$. Dushman's result has its chief success in gaseous reactions. This attempt to base it on statistical reasoning shows that it probably holds when the mechanism of the reaction is analogous to some such simple concept as the harmonic oscillator, but not if the nature of the reaction is more complex. T. B.

2315. *The Velocity of a Unimolecular Reaction.* **A. McKeown.** (Phil. Mag. 46. pp. 321–327, Aug., 1923.)—An empirical formula for the unimolecular velocity constant, *viz.* $k_1 = \nu e^{-h\nu/kT}$ has been shown by Dushman to agree with experimental data. The factor $e^{-h\nu/kT}$ represents the fraction of activated molecules present at any instant, and the factor ν denotes the frequency of some intramolecular occurrence necessary for the decomposition of an activated molecule. The author, assumes Einstein's concept of the mutual action of radiation and matter, and makes use of an assumption by Christiansen that the process of activation corresponds to the passage of a molecule from the normal state n to the activated state m, the difference of energy contents of these states being $\epsilon_m - \epsilon_n = h\nu$. He thus obtains the following expression for the velocity constant of a unimolecular chemical change: $k_1 = (p_m/p_n)(\nu . e^{-h\nu/kT})$, where p_m and p_n are the *a priori* probabilities of the states m and n. This equation differs from Dushman's empirical equation only in the factor p_m/p_n, which may be greater or less than unity, but is in no case a large numerical factor. T. B.

2316. *Velocity of a Unimolecular Chemical Reaction.* **W. C. M. Lewis.** (Phil. Mag. 46. pp. 327–329, Aug., 1923.)—Adopting Planck's expression for the rate of absorption of radiant energy by an oscillator, the author obtained a value for the velocity constant of a unimolecular change which was only one ten-millionth of that actually observed. The discrepancy can be accounted for by assuming a large value for the refractive index of an individual molecule. It is now shown that another assumption may be made which will lead to an equivalent result, namely, that the oscillator in a given time will absorb the energy which passes through an area comparable with λ^2/π, where λ is the wave-length of the radiation concerned in the chemical change. (This latter result was deduced by the late Lord Rayleigh for a *symmetrical* oscillator.) The final expression obtained for the unimolecular velocity constant is $k_{uni} = 8 \times 0{\cdot}17\nu . e^{-h\nu/kT}$, which is capable of giving values comparable with those obtained by the empirical equation of Dushman (see two preceding abstracts). T. B.

2317. *Radiation Theory of Chemical Reaction.* **H. S. Harned.** (Frank. Inst., J. 196. pp. 181–202, Aug., 1923.)—A summary and connected account of the radiation theory of reaction as developed by Trautz, Lewis, Perrin, Tolman, and Dushman. A considerable bibliography is appended. A. Wh.

2318. *On the Formation of the Explosive Wave.* **P. Laffitte.** (Comptes Rendus, 176. pp. 1392–1395, May 14, 1923.)—The object of the present investigation has been the study of the conditions of formation of the explosive wave in detonating gas mixtures. A mixture of carbon disulphide and oxygen has been employed, since this produces a flame endowed with great photogenic power. The length travelled over by the flame has been measured from the ignition of the detonating mixture to the establishment of the explosive wave, cylindrical glass tubes of variable diameter being employed for this purpose in conjunction with the photographic mode of registration as devised by Mallard and le Chatelier. Experimental details are included. On the photographs a curved zone is distinctly delineated showing the period of combustion at variable speed, and then, starting at a well-defined point, is the explosive wave propagated at constant velocity, whose image is in consequence limited to a straight line. The case is discussed of the formation of the explosive wave being retarded or expedited, and it was found that when the composition of the gaseous mixture is such that the quantity of carbon disulphide differs by more than 1 % from the theoretical value $CS_2 + 3O_2$, the wave is established with a retardation depending on the composition of the mixture. When the internal surface of the experimental tube is not perfectly regular and smooth the wave may start much more rapidly. This is seen especially when any discontinuity occurs, *e.g.* at a junction or at grains of dust or sand. H. H. Ho.

2319. *On the Propagation of the Explosion Wave. Part I. Hydrogen and Carbon-Monoxide Mixtures.* **H. B. Dixon and N. S. Walls.** (Chem. Soc., J. 123. pp. 1025–1037, May, 1923.)—From the published work of Berthelot, Bone, Wheeler, and Jouguet there appear to be three different conceptions of the way in which a flame may be propagated in explosive gaseous mixtures: (1) Each kind of molecule formed in the wave-front may carry it forward in turn with its own velocity *during equal intervals of time*; (2) as in (1), but *over equal distances*; and (3) that the propagation is independent of the motions of the individual molecules, but depends on their *mean velocity*. Experiments have been made on mixtures of hydrogen and carbon-monoxide Knall-gas with the idea of testing these theories. The explosions were carried out in a coiled lead pipe of 12·5-mm. internal diameter, velocities being measured between two silver " bridges " 69·156 metres apart. A firing piece of straight copper tube 1·45 metres long was used, and could be filled either with the same mixture as in the lead tube or with electrolytic gas through a by-pass. The latter method, however, appears to introduce a discontinuity in the explosion wave. Measurements of rates of the explosion wave in mixtures of H_2- and CO-Knall-gas showed that (except for mixtures very rich in H_2) the measured velocities agreed closely with the rates calculated from the times taken by each ingredient to travel equal distances (see (2) above). The discrepancy is explained on the assumption that at the high temperatures involved, the CO would be only partly burnt, and would act largely as an inert gas. Positive evidence on this point was obtained by employing N in place of CO. Experiments were also carried out on the explosion of mixtures of H_2 and CO with O in defect, with the further object of determining the division of the O between the two combustibles. It was found that when the products of the incomplete combustion of H and CO in the explosion wave cool down under conditions where all four gases are free to react, the " water-gas equilibrium," $(CO + H_2O)/(CO_2 + H_2)$, is found to be nearly constant; but whenever there is a chance of condensation of steam taking place during the secondary reactions the equilibrium is displaced. T. B.

2320. *The Propagation of Flame from a Spark in a Closed Tube through a Homogeneous Inflammable Mixture.* **O. C. de C. Ellis.** (Chem. Soc., J. 123. pp. 1435–1452, June, 1923.)—The propagation of the flame in mixtures giving a low speed of movement of the flame was photographed on a vertically moving film. The glass cylinders containing the inflammable mixture was horizontal. The mixtures used included C_2H_2 + air, C_2H_4 + air, CS_2 + air, $CS_2 + 3O_2 + 17N_2$, pentane + air, etc. It is shown that the movement of the flame in any given mixture depends on the length and bore of the tube, the position of the spark-gap, the initial turbulence, the intensity of the spark, and the initial temperature and pressure. As a basis of comparison of results, calculations are based usually on the average speed of the flame over the first 5 cm. The velocity at any point in the path of the flame is found to vary with the distance of the spark from the closed end towards which the ignition is spreading. It increases as this distance increases up to a certain point; after this, lengthening the tube or opening the end of the tube has no effect. The above remarks refer only to the initial phase (Phase I) which is characterised by regular acceleration. A second phase (Phase II) in the present experiments is observed, *viz.* one of slow and almost constant speed which lasts until the flame reaches the end of the tube. Phase II is frequently accompanied, especially if the mixture be a fairly fast one, by oscillations, these having no regularity of amplitude. It seems probable that the movement of flame in these mixtures is modified by mass movements of gas in the tube. The various movements are all found to be slower with a wider bore of tube. In general, Phase I shows an increase in speed due to turbulence of about 10 per cent.; Phase II shows a much greater increase. The speed of the flame measured over the first 4 cm. is found to increase with the capacity in the spark circuit up to a certain limit, when it becomes nearly constant. In the case of a higher temperature of the inflammable gas, the initial phase is found to be faster and the flame less luminous. In all the experiments tried on variation of speed with initial pressure of gas, the pressure for maximum speed has been found to be one atmosphere. T. B.

2321. *Reaction Kinetic Studies. Part I.* **H. v. Euler and E. G. Rudberg.** (Zeits. f. Physik, 16. 1. pp. 54–62, 1923.)—In a previous paper (Zeits. anorg. Chem. 127. p. 244, 1923) the authors have sought by means of certain hydrolytic reactions in aqueous solution catalysed by acids or bases: (1) To calculate the concentration of the activating ions termed *ri*; (2) to derive the ratio of *k* to the reaction constant *ri* measured in the same system, *i.e.* the quotient *k* : *ri* = *rq*. The present paper deals: (1) With the application of the basic principle to a reversible reaction; (2) with the mechanism of the hydrolytic processes; (3) with the calculation of the temperature coefficients based on the assumptions as to the course of the hydrolysis. The reversible reaction chosen is: ethyl acetate $\rightleftarrows$ acetic acid + ethyl alcohol, and this is considered in Section I. Previous work by Berthelot, Péan de St. Gilles, and Karlssen is also briefly reviewed. Sections II and III deal with the other cases above, previous work by the authors as also by Hedelius and Madsen being considered. The authors conclude that by acid catalysis, actual salt formation ensues with the formation of an oxonium salt. The entry of the hydrogen ion causes the ester molecule to acquire a positive charge, and the system being unstable splits up into the usual reaction products. The stability of the ester ion is given by its concentration (in equilibrium with ester and HCl) and by its calculated transformation velocity. The requisite energy for the formation of the ester ion is given by the hydrolytic constant of the salt ester – HCl, which, according to Nernst, is calculable from the dissociation constants.

H. H. Ho.

2322. *Lattice-Energy and Lattice-Distance of Mixed Crystals.* **H. G. Grimm and K. F. Herzfeld.** (Zeits. f. Physik, 16. 2. pp. 77–83, 1923.)—It is known from the study of mixed crystals that if two substances have the same type of crystal-lattice, their miscibility is better the smaller the difference of their lattice-distances and the higher the temperature [see Abstract 1745 (1922)]. At room temperature this difference is about 5 % for good miscibility. Vegard [Abstract 262 (1922)] showed from Röntgen-ray investigations that KBr and KCl form a mixed crystal of the NaCl type, *i.e.* of the same type as each component, Cl and Br being distributed at random in the lattice. When a simultaneous replacement of both ions occurs as in NaI and RbCl, distinct combinations are formed.

In order to determine the conditions of equilibrium which are important for the miscibility of the components we must investigate the heat changes which occur. In the case of mixed crystals the heat of formation or the heat of mixing can be calculated from quantities which refer to the pure components. The heat of formation at absolute zero is equal to the difference of the lattice-energies of the mixed crystal and of the pure components. Hence we have first to calculate the lattice-energy of the mixed crystal. Limiting the investigation to the case of a crystal in which the ions have equal charges and the same number of outside electrons, Born's theory states that the lattice-energy depends only on the lattice-distance, and for N pairs of kation-anion is given by

$$V = N\frac{e^2 a}{r}\left(1 - \frac{1}{n'}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where a depends on the lattice-type, e is the charge and n' the power of the repelling potential. Assuming (1) to hold for the mixed crystal, it follows that the difference between the lattice-energy of the mixed crystal and of the pure components is determined by the difference of the lattice-distances. The problem is therefore to calculate r the lattice-distance of the mixed crystal from the lattice-distances a and b of the pure components. Vegard concluded from his measurements that

$$r = ax + b(1 - x) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where x denotes the mol percentage of one component and $(1 - x)$ that of the other. The general lattice theory would indicate a different result, namely,

$$r^{n'-1} = x \,.\, a^{n'-1} + (1 - x)b^{n'-1} \quad \ldots\ldots\ldots\ldots \quad (3)$$

where $n' - 1 = 1$ according to Vegard, while lattice theory gives $n' - 1 = 8$ and therefore

$$r^8 = b^8 + (a^8 - b^8)x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

from which we find for a mixed crystal of 50 % KBr and 50 % KCl $r = 3{\cdot}228 . 10^{-8}$ cm., while Vegard's formula (2) gives $r = 3{\cdot}2211 . 10^{-8}$ cm. The author now finds that $n' - 1 = 3$ or $n' - 1 = 2$ give values for the mol-volume which are very close together and also close to observed values and that the observed values must be 10 times more accurate in order to determine the value of $n' - 1$.

The remainder of the paper consists of a comparison between the observed and calculated values of the heat of formation of mixed crystals. The heat of formation is found to have a small negative value in all cases. This negative value explains the breaking up of the mixed crystal at low temperatures. The calculated and observed values agree best when the empirical rule of addition of the molecular volumes is made the basis for the calculation of the lattice-distance. T. B.

2323. *On the Thermodynamics of Mixed Crystals.* **K. F. Herzfeld.** (Zeits. f. Physik, 16. 2. pp. 84–99, 1923.)—This paper is a mathematical development of the subject of the previous abstract. The author first develops an expression for the entropy of a mixed crystal. For problems of equilibrium he obtains by the use of Planck's function an expression for the thermodynamic potential for the mixed crystal and for the components. Since these are very complicated functions of the percentage of the components, he restricts his treatment to the critical point and to such low temperatures that each saturated mixed crystal consists practically of one component, thus enabling him to retain small quantities of the second order. The critical transition point phenomena are then discussed and some general conclusions are drawn, and the same remark applies to low temperature phenomena. The only case for which there appears to be any experimental data is that of a mixture of KCl and NaCl. The equilibrium phenomena between mixed crystals and mixed solutions is also treated by the help of the thermodynamic potential, and a partial agreement with experiment is obtained. The author finally considers the case of double salts and concludes that if his theory is sound, double salts must be considered definite chemical compounds. The paper must be consulted for the deduction of the equations (which are numbered continuously with those of the preceding abstract) and for numerical data. T. B.

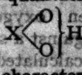
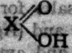
2324. *Displacement of Equilibrium in Solubility Problems.* **A. Colson.** (Comptes Rendus, 177. pp. 184–186, July 16, 1923.)—Correcting two errors in the formulæ of his previous paper [Abstract 2027 (1923)], the author points out that the broad statement of equality of action and reaction is misleading, and that the law cannot be verified when the heat of solution or the solubility is small, nor in concentrated solutions. Not because the laws of Mariotte and Charles are only approximations; but because, when a solvent of volume V dissolves a volume u, the final volume being U, the difference $(U - u)$ is not always positive; u may be of the same order or greater than either V or U. As regards concentrated solutions this arises, for instance, when ice is dissolved in alcohol, in which it is soluble in all proportions below $T = 273°$. As long as the temperature is sufficiently low, the V (alcohol volume) remains greater than the contraction due to the ice passing into solution, and the equality holds; but as more ice is being liquefied, $(U - u)$ becomes negative, whilst the heat of saturation L and the heat of solution ρ remain positive. Reference is also made to the case of sodium sulphate which has its maximum of solubility at 34° C. The general case is further discussed with respect to the influence of pressure on the solutions of bodies which expand or contract on dissolving. In saturated solutions the variation of the concentration is neither always, nor exclusively, balanced by the L or ρ, even at fixed pressure. H. B.

2325. *Electrometric Acidimetry and Alkalimetry without the Use of Hydrogen.* **P. A. van der Meulen and F. Wilcoxon.** (Indust. and Eng. Chem. 15. pp. 62–63, Jan., 1923.)—When a wire is immersed in dilute acid, together with a calomel half-cell as the other electrode, a fairly stable potential is obtained, this changing as the acid is gradually neutralised at a rate which becomes a maximum at the neutral point. With the help of a potentiometer with mirror galvanometer and scale, such an arrangement may be used for measuring potential differences, the titrations being conducted in a beaker and the solution stirred with an electrically driven stirrer; a thin, polished platinum wire is suspended in the beaker so that about 3 cm. is immersed, and a calomel half-cell of the saturated type is connected through a salt-bridge with the liquid in the beaker. For the mere location of the end-point of a titration, without tracing the entire course, the potentiometer is unnecessary. In this case use is made of a concentration cell consisting of two beakers, containing respectively the solution to be titrated and a solution with a hydrogen-ion concentration corresponding with the desired end-point. The beakers are connected through a salt-bridge and a platinum wire dipped in each, the two wires being connected through a tapping key with the galvanometer. The end-point is indicated by a change in the direction of the deflection. T. H. P.

2326. *Effect of Sucrose on the Activities of certain Ions.* **J. W. Corran.** (Am. Chem. Soc., J. 45. pp. 1627–1636, July, 1923.)—The conclusion previously found by Corran and Lewis (*ibid.* 44. p. 1673, 1922) that potassium and chlorine ions are soluble in the water of hydration of sucrose is now confirmed by measurements of the e.m.f. of potassium chloride concentration cells without transport, containing sucrose. The transport number of the potassium ion in sucrose solutions remains constant up to 50 % of sucrose, but appears to increase slightly in 60 and 70 % sucrose solutions. The barium ion also is soluble in the water of hydration of sucrose, and consideration of Harned's results (*ibid.* 42. p. 1808, 1920) shows that the chloride ion is soluble in the water of hydration of accompanying kations. Since the solubility or insolubility of an ion in water of hydration is of primary importance in determining its true concentration in terms of available water, Harned's extension to any ion of the MacInnes postulate regarding the independent activity of the chloride ion in solutions of univalent chlorides of the same concentration is valid only for those ions which are soluble in the water of hydration of secondary solutes (either ions or non-electrolytes). T. H. P.

2327. *A New Method for the Electrolytic Separation and Estimation of Halogens.* **G. Schay.** (Zeits. Elektrochem. 29. pp. 123–126, March 1, 1923. Paper read before the Deut. Bunsen Gesell, Leipzig, Sept. 1922.)—A method is devised for the analytical estimation of halogens by the separation of the bromine and iodine at the anode and removal from the electrolyte by maintaining at the boiling-point. The anode of the cell which is enclosed consists of platinum gauze and the kathode of a platinum spiral which is arranged to have a small surface relatively to the anode in order to hinder back reduction. The amount of material in the solution found most convenient is 0·1 mgrm. equivalent. About 20 c.c. of N-sulphuric acid saturated with bismuth oxide is added, 70 to 80 c.c. of 2N-sulphuric acid, and a quantity of distilled water. The excess of free acid is required to prevent the formation of iodate, bromate, or chlorate and the bismuth in order to obtain a definite metal potential at the kathode. Air is excluded by the boiling of the solution. A definite p.d. is maintained between the electrodes according to the particular halogen being separated and the electrolysis is completed in half-hour. The displaced halogen is collected in a solution of pure sodium hydroxide. In the case of bromine, potassium iodide is added and the iodine liberated estimated by titration with sodium thiosulphate. With a mixture of halogens in the electrolyte, iodine and bromine can be separated from each other within certain limits by adjusting the potential. An accuracy within 0·1 to 0·2% is obtained. Chlorine cannot be quantitatively displaced, but can be estimated in the electrolyte after removal of the other halogens. J. N. P.

2328. *Theory of Electrolytes. Part I. Freezing-Point Depression and Cognate Phenomena.* **P. Debye** and **E. Hückel.** (Phys. Zeits. 24. pp. 185–206, May 1, 1923.)—In order to account for the anomalies of electrolytic dissociation, Bjerrum [Abstract 946 (1920)] introduced two coefficients, the osmotic coefficient f_o into the formula $P = f_o P_k$, and the activity coefficient f_a into the Guldberg-Waage formula for the equilibrium constant, $c_1^{\mu_1} . c_2^{\mu_2} \ldots c_n^{\mu_n} = f_a K$. Both these coefficients depend upon the concentration of the solution, but not in the same way. Rejecting the arguments of Ghosh [Abstracts 104 and 223 (1919)], the authors, in their mathematical considerations of the influences of the static charges of the ions (of vanishing or definite diameter) and of thermodynamical potential and freezing-point depression, deal mainly with f_o and f_a; but their f_a is not quite that of Bjerrum. The conductivity data are taken chiefly from recent American determinations. The following conclusions are drawn: (1) The deviations (per cent.) from the classical values of the freezing-point depression are, at low concentrations, proportional to the square root of the concentration; (2) when the dissolved molecule dissociates into several ions $\nu_1 \ldots \nu_i \ldots \nu_s$ of different kinds and of different valencies z, these deviations are also proportional to the valency factor w, defined by $w = (\Sigma \nu_i z_i^2 / \Sigma \nu_i)^{3/2}$; for KCl, $w = 1$; for $CaCl_2$, $w = 2\sqrt{2} = 2{\cdot}83$; for $CuSO_4$, $w = 4\sqrt{4} = 8$; for $AlCl_3$, $w = 3\sqrt{3} = 5{\cdot}2$; for $Al_2(SO_4)_3$, $w = 6\sqrt{6} = 16{\cdot}6$; (3) again at low concentrations, these deviations are further inversely proportional to the 3/2 power of the dielectric constant of the solvent. The considerations show that the electric energy of an ionic solution cannot essentially be determined by the distance between the ions. The characteristic quantity is the thickness of the Helmholtz layer, and as this thickness depends upon the concentration, the electric energy is also a function of the concentration. Though one cannot speak of a lattice-structure of an electrolytic solution in the strict sense, each ion will be surrounded by ions of the opposite charge, as in NaCl crystals; but the orientation will, in the solution, be influenced by the thermal equilibrium. Calculations are generally based on the assumption of the ordinary value of the dielectric constant of the solvent. On the dipole theory dielectrics should, however, in intense fields, show saturation phenomena, similar to magnetic saturation, Herweg [Abstract 1378 (1922)]; this saturation should affect the phenomena, since the field intensity would be about 200,000 volts/cm. at a distance of 10^{-7} cm. from an ion carrying a single charge. It is further to be considered that the many ions in the neighbourhood of a particular ion will affect the electric character of the medium and the migration and freezing-point phenomena. When nitric acid of a certain concentration is diluted, there will first be heating, but on continued dilution cooling will set in, because work has to be done further to separate the ions. Starting from an acid of higher concentration, the same experiment would show a heat evolution. This would influence the hydration phenomena and the freezing-point depression. When a charge is set up in the interior of an electrolyte, the equilibrium distribution cannot be calculated on the Boltzmann-Maxwell principle; Brownian movement and a time effect come in. Anticipating, the authors state that the complete dissociation of strong electrolytes is confirmed. H. B.

2329. *The Theory of Ionogenic Binding as Basis of an Ionic Theory Deduced from an Investigation of Non-Ionised Acids.* **A. Hantzsch.** (Zeits. Elektrochem. 29. pp. 221–246, June 1, 1923.)—The author accepts neither the theory that chemical reaction of acids in particular is restricted to the ions formed in the solutions, nor the view of Bjerrum and R. Lorenz that the non-dissociated portion of electrolytes is likewise concerned in reactions, but suggests—in the first instance, on the strength of optical researches by the late K. Schaefer and of his own work on organic acids—that the so-called ionising action of water is purely chemical, and that acids consist of two or three modifications, true acids, pseudo-acids, and equilibrium acids. (1) True acids are electrolytes, heteropolar hydrogen compounds, chemically active, optically resembling salts, containing hydrogen atoms ionogenically bound and directly replaceable by more positive metals or complex kations without any constitutional change or essential optical change (absorption spectra). The true strength of these acids (acidity) is determined by their tendency to form salts while in the non-dissociated condition, *i.e.* by the degree of stability of their salts; the acids form with water or in aqueous solutions hydroxonium salts which, being unstable, react qualitatively like the free acids, but less strongly. This acid type is  $X\left\langle\begin{matrix}O\\O\end{matrix}\right\}H$ or $[XO_2]'H$. (2) Pseudo-acids, chemically inactive (of acid character apparently), optically resembling esters, are homopolar hydrogen compounds containing their hydrogen atoms, which are in themselves inactive, bound in oxygen acids as hydroxyl to an oxygen atom and ready to pass, by addition of water, partly or entirely, into hydroxonium ions, but not without constitutional and optical change; qualitatively they may behave like true acids and might be called pseudo-electrolytes. Their type is  $X\begin{matrix}{/\!\!/}O\\ \backslash OH\end{matrix}$ or OX . OH. (3) Equilibrium-acids, intermediate between the two. Thus trichloro-acetic acid, when dissolved in indifferent hydrocarbons (pentane), is optically an equilibrium-acid containing 90 % of true and 10 % of pseudo-acid; this pentane solution does not conduct and is therefore not dissociated; yet it is more reactive than an aqueous dissociated solution. Acetic acid itself contains only 0·1 % of true acid. Similarly true salts and pseudo-salts are distinguished. The acidity changes with the solvent. The acids which, by oxygenous non-dissociating solvents (ether, etc.) are changed so as to become similar to esters, are at the same time converted into pseudo-acids. Optically the acid stands between the salt and the ester. The acidity of acids (when in non-dissociated solutions) is determined by the rate of inversion of cane sugar, by the rate of decomposition of diazo-aceto-esters, and by the aid of indicators. Perchloric acid is the strongest acid, being in N/70,000 solutions in ether still as strong as nitric acid is in 0·45 N-solution. Many true acids and acid salts do not exist in the solid state, *i.e.* they are then inactive and are merely pseudo-acids. The ionogenic binding is identical with the electronic binding, the hydrogen atom having passed its electron on to the acid ion. Water has a levelling action; it makes strong acids less active, and weak acids more acid, because it does not primarily dissociate the acid, but combines with it to form oxonium salts. In forming addition compounds water does not occupy a singular position, and any reactions between non-electrolytes should not be ascribed to faint dissociation. The theories of Werner and of Berzelius are discussed, and the author may be said to revert more to the views of Berzelius. H. B.

2330. *Electrochemical Behaviour of Bismuth and Antimony in Alkaline Solutions.* **G. Grube** and **F. Schweigardt.** (Zeits. Elektrochem. 29. pp. 257–264, June 1, 1923.)—The anodic behaviour of the metals (cast plates) is studied in apparatus similar to those mentioned in Abstract 1267 (1923). In concentrated caustic potash bismuth is always dissolved as tervalent ion, bismuthite being formed. Up to 1 gr. of Bi can in this way be dissolved per litre; when this concentration has been reached, the bismuth becomes coated with coloured higher oxides, and the electrolysis is interrupted. Antimony also yields tervalent solutions, but concentrated solutions of potassium antimonite can be obtained, and the passivity, due to the formation of a white oxide coating, only sets in at high current-density, exceeding 7·5 amp./cm.^{2}. The potassium antimonite produced by the electrolysis is a strong reducing agent and absorbs oxygen from the air, yet the anodic oxidation to antimonite is not reversible and not a direct oxidation, but due to the liberated gaseous oxygen; oxygen is evolved. From the reaction the potential of antimony against a solution containing at 20° 1 gramme ion of SbO_3' in 10N-KOH is calculated to be $\epsilon_k = -0{\cdot}641$ volt; the potential cannot be determined directly. The more alkaline the solution of potassium antimonite in caustic potash, the more effective it will be as a reducing agent. H. B.

2331. *On the Complex Ions formed by Silver Salts and Ammonia or Substituted Ammonias.* **P. Job.** (Comptes Rendus, 176. pp. 1805–1808, June 18, 1923.)—In a previous paper (Comptes Rendus, 176, 442–445, Feb. 12, 1923) the author has shown that silver salts form two complex ions with ethylene diamine of formula $(Ag\,en_2)^+$ and $(Ag\,en)^+$. The same method is now used for substituted ammonias and ammonia. Diethylamine in concentrated solution gives a complex ion

$$\{Ag\,[(C_2H_5)_2NH]_2\}^+,$$

whose stability is slightly less than the similar ethylene diamine ion, but in solutions more dilute as regards diethylamine, the results obtained can only be interpreted on the assumption of the formation of a complex monamine $\left\{Ag\,[(C_2H_5)_2NH]\right\}^+$. Hexamethylene tetramine gives two complex ions $\left\{Ag\,[(CH_2)_6N_4]_2\right\}^+$ and $\left\{Ag\,[(CH_2)_6N_4]\right\}^+$, whose stability is much less than those above. Finally concentrated ammonia gives with silver an ion of formula $[Ag\,(NH_3)_2]^+$, but in dilute solution complication ensues and a simple interpretation of the results has not been possible. The paper concludes with a study of the effect of temperature on the stability of the various silver diamine ions, the results being given in tabular form. H. H. Ho.

2332. *Constitution of Persalts, particularly Percarbonates and Perborates.* **M. Le Blanc** and **R. Zellmann.** (Zeits. Elektrochem. 29. pp. 179–187, April 1, and pp. 192–198, May 1, 1923. Paper read before the Deut. Bunsen Gesell., Leipzig, 1922.)—The earlier work on persalts is reviewed, and the methods for their preparation is discussed. The chemical methods for the preparation of sodium percarbonate and sodium perborate is described. The salts $Na_2C_2O_6$ and $NaHCO_4$ were prepared in a comparatively pure state. It was shown that the reaction $NaBO_2 + H_2O_2 = Na[BO_2H_2O_2]$ was the basis of all the apparently different methods of preparation of sodium perborate. The name of pseudoperborate was given to this perborate.

Two new perborates were prepared, a true sodium perborate and the potassium pseudoperborate. The first was obtained according to the reaction $NaOOH + H_3BO_3 = NaBO_3 + 2H_2O$, while the second was formed when 3 % H_2O_2 was added to a dilute solution of potassium metaborate. The effects of current-density, temperature, and materials, on the current yield, in the electrolytic preparation of percarbonates and perborates were studied. The persalts are classified, and the relationship of di- and mono-persalts described. The results showed that reactions were ascribed to di-persalts which are characteristic of the mono-persalt produced by hydrolysis. The basisity of the mono-persalt is $n-1$, when n is the basisity of the normal compound. The true perborates occupy a special position. A method of differentiating between true persalts and addition compounds with H_2O_2 was investigated and applied to sodium perborate and sodium percarbonate. F. J. B.

2333. *Ionising Properties of Molten Lithium Hydride.* **A. Guntz** and **Benoit.** (Comptes Rendus, 176. pp. 970–971, April 9, 1923.)—Experiments are described indicating that lithium carbide is in an ionised condition when dissolved in molten lithium hydride. The minimum voltage necessary for the deposition of carbon on the anode is found to be about 0·05 volt. Similar effects are noted with calcium carbide dissolved in pure calcium hydride free from chloride, and with the nitrides of the same metals correspondingly treated. A. B. C. L.

2334. *Transference Numbers of Sodium and Potassium in Mixed Chloride Solution.* **R. F. Schneider** and **S. A. Braley.** (Am. Chem. Soc., J. 45. pp. 1121–1134, May, 1923.)—Measurements are described of the transference numbers of sodium and potassium and of the transference ratios in mixtures of their chlorides in solutions ranging in concentration from 0·1 to 1·6N and with values of the ratio KCl : NaCl lying between 3 : 1 and 1 : 3. The equivalent conductivities are also given for the mixed solutions and the mobilities of the ions are calculated from the transference numbers.

The results obtained show that the solutions are highly complex and are not in accord with the hypothesis of complete dissociation. When the total concentration is 0·2N and the ratio KCl : NaCl is 3 : 1, the mobility of the sodium ion is practically zero. The observed deviations between the calculated and experimental values of the transference ratios are due not to hydration of ions alone but also to the formation of complexes in solution. The results agree with those of Smith and Ball (*ibid.* 39. p. 179, 1917) and of Smith and Wells (*ibid.* 42. p. 185, 1920), who found that the sodium-ion fraction increases with increase in total concentration above 0·2N; at lower concentrations the sodium decreases with respect to the potassium. T. H. P.

2335. *Exchange of Ions in Dielectrics. Part I. The Electrode Function of Glasses.* **K. Horovitz.** (Zeits. f. Physik, 15. 6. pp. 369–398, 1923.)—It is shown that certain kinds of glass behave as solid electrolytes. In two kinds of glass, one containing over 10 % Si, B, Na, and under 10 % Al(Mn), the other over 10 % Si, Na, and under 10 % B, Al, K(AsMn) in a solution containing sodium ions behave as reversible Na-electrodes, while two other glasses, one containing over 10 % SiNa and under 10 % BAlCaZn(Mn), another over 10 % SiBZn and under 10 % AlNa(As) behave like reversible Zn-electrodes. The taking up of H- and metal ions into the glass is shown to be an adsorption exchange. If the adsorbed ions are taken up in such quantity that they cause a decided potential they form a mixed-electrode of which the solution pressure is variable. A connection is shown to exist between the improvement of the H-electrode function and the ease of attack of the glass. A. E. G.

2336. *Separation of Isotopes.* **J. Kendall** and **E. D. Crittenden.** (Nat. Acad. Sci., Proc. 9. pp. 75–78, March, 1923.)—In view of the difficulty attending the complete resolution of a complex element by diffusion and evaporation methods, the two following methods are suggested for the separation of isotopes.

The ionic migration method, which utilises the principle of the moving boundary, is applicable to the case of chlorine in the following manner. An agar-agar gel containing sodium chloride and forming a short section in a long horizontal tube, is bounded at its two ends by gels containing sodium hydroxide and sodium acetate respectively, these two gels being continued into the turned-up ends of the tube. When the two gels have set, concentrated sodium hydroxide and a solution of sodium acetate in concentrated acetic acid are poured above them, and a platinum anode and kathode inserted in the respective liquids. When a current is applied by means of a 110- or 220-volt lighting circuit, the heating effect of the current on the gel being minimised by means of external lamp resistances or by cooling the tube with running water, the boundary surfaces between the various sections of the gel move towards the anode. When the front chloride boundary almost reaches the end of the tube, the two rear sections of gel are discarded and two new sections filled with hydroxide gel inserted in front of the chloride and the procedure repeated. If the isotopic chlorine ions with atomic masses

35 and 37 possess appreciably different mobilities, they should undergo separation in this way. Preliminary experiments show that sodium iodide and sodium thiocyanate are separable by this means and further applications are in progress.

The discharge potential method depends on the fact that, owing to the concentration of C_{35} in natural chlorine being more than thrice that of C_{37}, the discharge potentials of the two species of chloride ion in any naturally occurring solution should, provided that the Nernst concentration equation applies, differ by about 0·03 volt. Hence, if such solution is electrolysed by application of a voltage such that the decomposition potential of one species is just exceeded and that of the other species not attained, separation should be possible. This method is being developed. T. H. P.

2337. *The Phenomenon of Electrical Supertension. Part III.* **A. Smits.** (K. Akad. Amsterdam, Proc. 26. 3 and 4. pp. 259–265, 1923. In English.)—In the author's book, " Die Theorie der Allotropie," and also in previous communications [see Abstract 1446 (1919)], the subject of electrical supertension has only been treated briefly, so that the present paper considers the matter at length. The experimental case is discussed of hydrogen for one electrode and palladium (or platinum) for the other, the electric potential of the electrodes being plotted as a function of the concentration. It is found that in the case of electrolytic generation of hydrogen, the states of formation of the hydrogen in the coexisting hydrogen and palladium phases are very closely related, and that the kathode metal can exert influence on the degree of supertension. The state of formation is one of non-equilibrium, and different kathode metals will variously accelerate the conversion of this state of non-equilibrium in the direction of the inner equilibrium, thus providing the reason why the so-called supertension of hydrogen varies with the metallic kathode. The temporary variations of supertension have to be explained by the slow change in constitution of the coexisting phases. The heterogeneous equilibrium between the boundary layers is established with great velocity, but the composition of the phases changes slowly, and to this must be ascribed the slow change of the three-phase equilibrium metal-electrolyte-hydrogen. Analogous considerations apply to oxygen and other non-metals, where the assumption is necessitated that the atoms of all elements can split off and receive electrons, a supposition required for the explanation of the positive charges of non-metals with regard to electrolytes, of the small electric conductivity of non-metals in electrically neutral condition, and of the formation of compounds between metals. H. H. Ho.

2338. *Electro-Chemistry of Non-Aqueous Solutions.* **R. Müller.** (Samml. Chem. und chem.-techn. Vorträge, 27. pp. 243–358, June, 1923.)—The dielectric constant proves to be one of the most fundamental determinants in the properties of solvents. Values for a large number of organic compounds are tabulated. A high value is obtained by the combination of two groups of the highest electrical contrast, the electronegative radical such as $-$ OH, $-$ NO_2, which has been termed the di-electrophore and the positive group or dielectrogen of which the most active is H. The interrelation between cohesive force, dielectric constant, and the bipolar relation of molecules, and its bearing on the asymmetric structure of molecules is discussed. The bipolar properties of solvents are best reconciled with the view that the lighter elements, C, N, O, and F possess a tetrahedral rather than a cubic symmetry in the outer ring of electrons.

In the case of a large number of organic bodies in non-aqueous solvents a review with tables and references to the literature is given of results of measurements on the degree of dissociation or association and electrical conductivity. Non-aqueous solvents are as a rule characterised in giving marked deviations from the Ostwald dilution law, though in the case of binary salts of strong acids and bases in alcohol, acetone, or pyridine, the relation followed is similar to that with water, and a limiting value is attained for the molecular conductivity. A universal dilution formula which has been derived by Walden is of the form: $\alpha_v \epsilon \eta_\infty v^{0.5} =$ constant, where α_v is the degree of dissociation at the dilution v, ϵ the dielectric constant, η_∞ the viscosity of the solution at the limiting dilution. The subjects reviewed also include the following: Temperature coefficients of conductivity, ionic mobilities, and transport ratios. Causes of abnormalities in non-aqueous solutions, *viz.* solvolysis, association of solute and of solvent with solute, and the change of dielectric constant of solutions with concentration. The dielectric constant of a solvent is increased by the undissociated portion of the solute and not by the ions which are not bipolar. Departures from the Ostwald dilution law are accounted for in accordance with this effect. A discussion is given of work which has been conducted on electrostriction, anomalous electrolytes and new theories of electrolytic dissociation which have been put forward including the view of Kossel that the driving force of dissociation is the heat of hydration or solvation of the ions and increases with diminishing radius of the ions, and the hydro- and electro-dynamic considerations determining dissociation which have been investigated. The results are enumerated of measurements which have been made on the p.d. between metals and non-aqueous liquids, boundary potentials, and oxidation and reduction potentials in non-aqueous solutions. A chapter is devoted to the electrolytic separation of metals from organic electrolytes. J. N. P.

2339. *The Effect of Pressure on Over-Voltage.* **H. M. Goodwin** and **L. A. Wilson.** (Am. Electrochem. Soc., Trans. 40. pp. 173–184, 1921.)—Experiments are described in which the over-voltage of hydrogen against copper, nickel, and mercury electrodes was determined under pressures varying from one atmosphere to a few centimetres of mercury. The values were determined by the bubble method, at room temperature, under conditions of very low current-density, after a state of constant polarisation had been established. The results in all three cases showed a rapid decrease at low pressures, confirming the hypothesis recently advanced by MacInnes and Adler to explain over-voltage phenomena. AUTHOR.

2340. *Cause of Adhesion and Magnitude of Electrolytically Evolved Gas Bubbles.* **A. Coehn.** (Zeits. Elektrochem. 29. pp. 1–5, Jan. 1, 1923.)—A series of determinations were made of the discharge potential, and the size of the gas bubbles evolved when solutions of $0\cdot1n$ H_2SO_4 and $0\cdot1n$ KOH were electrolysed. Electrodes of nickel and silver were employed. The adhesion of the bubbles to the electrodes was found to be due to the electrostatic attraction of the kathode to the positively charged gas bubbles, aided by capillary forces.

The maximum size of the bubbles was measured by a micrometer ocular, and it was found that the maximum size was a function of the concentration for a given solution. F. J. B.

2341. *An Effect of the Electrostatic Charge of Electrolytically Developed Gas Bubbles.* **A. Coehn.** (Zeits. Elektrochem. 29. pp. 306–308, July 1, 1923.)—It is to be expected that when employing a kathode of palladium or other metal capable of absorbing hydrogen, the absorption of gas will be affected by the electrical charge on the gas bubbles which is found in the above work to determine the size of the bubbles and their adhesion to the electrode. By means of eudiometer tubes, measurements are made of the volume of hydrogen evolved from palladium kathodes during electrolysis of sulphuric acid of different concentrations with definite currents. It is found that the amount of hydrogen absorbed increases with increasing concentration of the acid up to a certain limit and then falls slightly. The curve giving the relation between the volume of gas absorbed and the concentration of acid is of the same type as that showing the magnitude of the charge on the bubbles with concentration of acid when a stream of gas is bubbled mechanically through the solution, but, in the former case, is displaced so as to give a maximum at a higher concentration of acid than in the latter case. This displacement is attributed to the fall in concentration around the kathode during electrolysis whereas the concentration remains unchanged during the mechanical bubbling. With potassium hydroxide, a smaller absorption or higher gas evolution occurs in accordance with the observation of the negative charge on the bubbles and consequent lower adhesion to the electrode. Similar absorption relations are observed with other metals such as tantalum, nickel, and iron by using other methods. J. N. P.

2342. *Electrolytic Deposition of Chromium.* **E. Liebreich.** (Zeits. Elektrochem. 29. pp. 208–210, May 1, 1923. Paper read before the Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The electrolytic deposition of chromium from chromic acid is discussed and the previous work of Sarjent [see also Abstracts 682 (1922) and 586B (1923)] is criticised. The paper does not lend itself to abstracting. F. J. B.

2343. *Electrolytic Zinc.* **M. v. Schwarz.** (Zeits. Elektrochem. 29. pp. 198–207, May 1, 1923. Paper read before the Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The structure of electrolytic zinc was investigated, and it was found that the zinc is deposited with the crystals at right angles to the kathode surface. The chemical analysis of electrolytic zinc showed that it contained 99·85–99·9 % zinc, with small quantities of iron, copper, lead, and enclosed electrolyte as impurities. It was found that, when electrolytic zinc was healed to 105° to 110° C., a considerable amount of hydrogen was evolved. Dilatometer measurements showed a normal rise indicating the absence of a change of form. Carefully made measurements of the hydrogen evolved when kathode zinc, containing copper = 0·0140 %, lead 0·0700, iron 0·064 %, and 99·8519 % zinc, was dissolved in acid gave 0·049 % by weight of hydrogen occluded by the zinc. Remelted kathode zinc gave practically the theoretical volume of hydrogen. F. J. B.

2344. *The Anodic Oxidation of Gold.* **F. Jirsa** and **O. Buryànek.** (Zeits. Elektrochem. 29. pp. 126–135, March 1, 1923. Paper read before the Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—It has been previously demonstrated that gold dissolves by anodic polarisation in a solution of dilute sulphuric acid to give $Au(OH)_3$. In the present work it is found that the reaction is best conducted by enclosing the anode in a linen diaphragm and placing a small crucible underneath to collect the hydroxide. It is necessary to employ a c.d. at the anode of 1 amp./cm.^{2} and to cool the electrolyte by immersing a coil through which water is circulated. A considerable amount of ozone is formed, the quantity increasing with the concentration of sulphuric acid and with the c.d., which is in distinction from the case of platinum anodes where the formation of ozone diminishes with increase of acid. The results in the case of platinum are attributed to the production of a layer of salts which are only slightly soluble in the concentrated acid, while the solubility of the gold hydroxide increases with the concentration of acid accompanied by a fall in the passivity. The oxidation stages are investigated by means of potential measurements during electrolysis under different conditions, and determinations are made of the potential of the electrodes Au/Au_2O_3 and of gold in sulphuric acid solutions and of a charged gold anode during depolarisation. A rapid depolarisation is produced by the application of an alternating current whereby a suspension of gold and no oxide is produced. In this process, $Au^{\cdot\cdot\cdot}$ is produced during the positive phase and reduced to $Au^{\cdot}$ during the negative phase. By hydrolysis this reacts as follows: $3\,Au^{\cdot} \rightleftarrows 2\,Au + Au^{\cdot\cdot\cdot}$ until finally the $Au^{\cdot}$ ion is eliminated to give metal.

The anodic oxidation of gold by d.c. is considered to proceed in the following stages:

(1) $Au \longrightarrow Au^{\cdot}$, or the metal dissolves in the active condition to give aurous sulphate, a reaction which occurs at 1·07 volts when measured against a hydrogen electrode.

(2) $3\,Au^{\cdot} \longrightarrow 2\,Au + Au^{\cdot\cdot\cdot}$, when hydrolysis occurs producing basic sulphate and $Au(OH)_3$, giving a secondary formation of gold hydroxide on the anode and leading to passivity of the electrode.

(3) $Au \longrightarrow Au^{\cdot\cdot\cdot}$. This occurs at an anodic potential of 1·24 volts, when an active condition is again obtained to be followed by hydrolysis and formation of $Au(OH_3)$ at the anode, followed by passivity.

(4) $Au^{\cdot\cdot\cdot} \longrightarrow Au^{\cdot\cdot\cdot\cdot} \longrightarrow Au^{\cdot\cdot\cdot}$. The auric oxide is oxidised to AuO_2 which decomposes into Au_2O_3 and free O_2. Through the operation of overvoltage the free evolution of O_2 by direct electrolysis first occurs at 1·75 volt. On account of hydrolysis of the Au_2SO_4, the reactions $Au \longrightarrow Au^{\circ\cdot}$ and $Au^{\cdot} \longrightarrow Au^{\cdot\cdot}$ are precluded. J. N. P.

2345. *Electrolysis in Liquid Sulphur Dioxide.* **M. Centnerszwer and J. Drucker.** (Zeits. Elektrochem. 29. pp. 210–214, May 1, 1923. Paper read before the Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—A series of experiments on the electrolysis of sodium iodide and potassium iodide in liquid sulphur dioxide, was made. The temperature was kept at $-18°$ to $-21°$ C. and loss of solvent was avoided by means of a reflux condenser. It was found that when sodium and potassium iodide were electrolysed in liquid sulphur dioxide, an unstable product was obtained at the kathode. This is probably due to the primary separation of the alkali metal which reacts with the solvent and formed hydrosulphite, which in turn decomposed into thiosulphate and pyrosulphate. The separation of sulphur at the kathode was not observed. When pure dry sulphur dioxide was electrolysed by high-voltage current sulphur was deposited at the kathode. This confirms the assumption of Walden that fluid sulphur dioxide contains positive charged sulphur ions.

F. J. B.

2346. *Anodic Formation of a Perchloride of Manganese.* **A. N. Campbell.** (Chem. Soc., J. 123. pp. 892–894, April, 1923.)—In the course of experiments on the kathodic deposition of manganese from chloride solution, the solution round the anode, which was separated from the main body of the liquid by a porous pot, assumed a very deep red colour and was found to contain the tetrachloride $MnCl_4$. The latter is sensitive to light, especially ultra-violet light, the solution losing its dark colour and giving off chlorine without, however, any precipitation occurring. The results of oxidation–reduction potential measurements give for the normal potential of quadrivalent manganese-ions in presence of bivalent manganese-ions the value 1·465 volts (hydrogen scale) at 16°.

T. H. P.

2347. *Electrolytic Preparation of Mercury Dimethyl.* **J. L. Maynard** and **H. C. Howard.** (Chem. Soc., J. 123. pp. 960–964, May, 1923. Paper read before the Am. Chem. Soc., April, 1922.)—In view of the poor yields obtainable by the methods available for the preparation of mercury dimethyl, a new electrolytic method was developed. When solution of methyl-mercuric halides in liquid ammonia, water, or alcohol are electrolysed, the complex MeHg — is deposited in the kathode as fine black flakes, which decompose at ordinary temperatures into mercury and mercury dimethyl:

$$2\mathrm{MeHg} - \longrightarrow \mathrm{Hg} + \mathrm{HgMe_2}$$

The electrolyte used consisted of an aqueous 25 % solution of methyl-mercuric acetate to which pyridine was added in the proportion of 2 mols pyridine to 1 mol of the organomercuric salt. The kathode was a sheet of smooth platinum foil, and two graphite rods formed the anode. The temperature of the electrolysis was 30°–40° C. A potential of 30–35 volts maintained a current of 2·5 amps., but as the concentration of the methyl-mercuric salt decreased the current fell. In an actual preparation 106·5 g. of methyl-mercuric acetate in the form of a 25 % solution, with 2 mols pyridine added per mol of acetate, an average current of 1·67 amps. was passed for 2 hours 10 min., the total ampere hours being 10·64.

The current yield demanded by theory was 46·1 g. while that obtained was 41·4, corresponding to a current efficiency of 90 %. F. J. B.

2348. *The Electrolytic Oxidation of Formic Acid.* **E. Müller.** (Zeits. Elektrochem. 29. pp. 264–274, June 1, 1923.)—According to various investigators the electrolytic oxidation of formic acid yields, at the anode, CO_2 and oxygen in proportions varying with the conditions. Acetic acid electrolysed also yields hydrogen which, in the case of formic acid, might further be oxidised to water. The reaction between formic acid and rhodium, palladium, and especially osmium, likewise liberates hydrogen. The author therefore investigated whether the electrolysis of formic acid would yield hydrogen by a kind of " inner oxidation by the hydrogen ion," as it did in the case of formaldehyde (*ibid.* 28. pp. 307–310, July 1, 1922). Electrolysing formic acid or sodium formate (neutral, acidified, or alkaline) with anodes of platinum (platinised, smooth, or coated with rhodium), palladium, and iridium, and raising the anode potential gradually, he observed that oxidation to CO_2 and H_2O took place at low potentials (about 0·1 volt) and then stopped, as the potential was raised, setting in again at about 1 volt. The electrolysis may thus take place in two stages: the first, at low potential, when the metal acts catalytically; the second, at higher potential, when the anode is more or less oxidised. There was no clear evidence of a liberation of hydrogen. H. B.

2349. *Synthesis of Ammonia from its Elements in the Low-Voltage Arc.* **H. H. Storch** and **A. R. Olson.** (Am. Chem. Soc., J. 45. pp. 1605–1614, July, 1923.)—When an apparatus similar to that used by Andersen [Abstract 2162 (1922)] is employed, the fatigue of the absorption mechanism is rapid, and the quantities of hydrogen absorbed by the platinum anodes are comparatively large, so that it becomes necessary to establish the equilibrium of the anodes before each determination, which is a tedious operation. An apparatus has therefore been devised to overcome these inconveniences.

The wave type of curve obtained by Andersen as an expression of the rate of reaction of nitrogen and hydrogen as a function of the accelerating voltage is found to be due to superposition of the curve described below, and a "fatigue" factor in the mechanism used for absorbing the gaseous ammonia. At constant tube current, the variation of the rate of the reaction with the accelerating voltage is such as to give abrupt increases in the rate of reaction at specific voltages which are about 4 volts apart. The formation of ammonia in sufficient quantity to be detected by Nessler's reagent does not occur except in presence of an arc. The magnitude of the rate at any given voltage and at constant tube current depends primarily on the diameter of the hot filament used as the source of electrons. Increased rate of reaction is favoured by an increased proportion of nitrogen in the gases. T. H. P.